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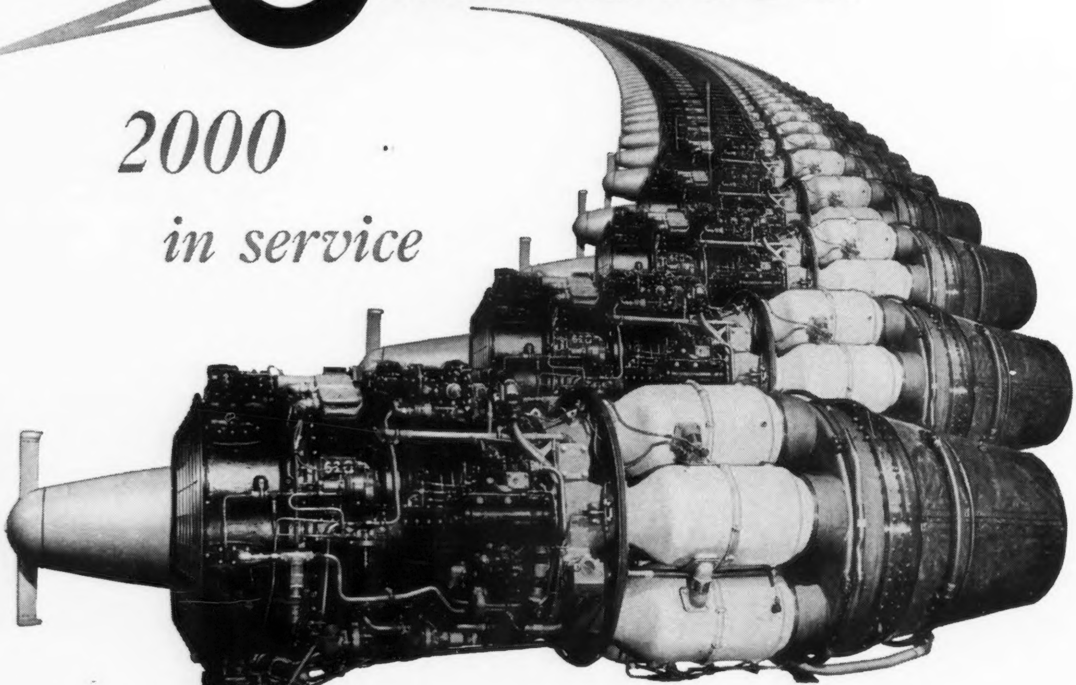
ORENDAS...

2000 in service



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CANADIAN AERONAUTICAL INSTITUTE

COUNCIL 1954-55

CANADIAN AERONAUTICAL JOURNAL

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MENTOR

The Mentor T-34A pilot-training aircraft is built in Canada by Canadian Car and Foundry Company Limited under license from the Beech Aircraft Corporation. The design is based on the use of the Bonanza wing and incorporates a tricycle landing gear. The aircraft is powered by a Continental E-185 six-cylinder horizontally opposed aircooled piston engine which drives a constant speed propeller.

EDITORIAL

THE POWER OF PRINT

THERE is power in the printed word. Francis Bacon, one of the founders of modern science, recognized this over 300 years ago. In his famous "Novum Organum" of 1620 he said, "It is well to observe the force and virtue and consequences of discoveries; and these are to be seen nowhere more conspicuously than in those three which were unknown to the ancients, and of which the origin, though recent, is obscure and inglorious; namely, *print*, gunpowder, and the magnet. For these three have changed the whole face and state of things throughout the world . . ."

And Wilbur Wright has told how he read of the death of Otto Lilienthal in a glider accident in 1896. Instantly a slumbering interest in flight was awakened. He thought of the birds, and reached for a well thumbed book in his library, "Animal Mechanisms" by Professor Marey. Then he and his brother drove forward, to change the whole face and state of things with powered flight.

With such a scientific heritage in the printed word, it is not surprising that we, who were fortunate enough to be in office during the early days of the C.A.I., have been continually searching for ways and means to bring forth a properly printed journal. But today we pass over the threshold. Today you have in your hands the first copy of the CANADIAN AERONAUTICAL JOURNAL.

As elementary as this first edition may seem, it has been put together against a backdrop of almost two years of investigation, indecision, a slow groping forward. I think it is significant that there has never been a meeting of the Interim Council, or the Council, where thoughts on a publication have not found their way into the minutes—from the first exploratory session that started the C.A.I. in August 1953, until today.

For the Council, and active members everywhere, have always felt that the object of the C.A.I., "to advance the art, science and engineering relating to aeronautics," can only really be achieved through the power of print. We can hold lectures, we can have informal get-togethers—but the real exchange of technical ideas that will bring forth the best in Canadian aviation, can only be achieved through the printed word.

With this background, the Secretary, and members of the Publications Committee, J. Lukasiewicz and H. C. Oatway, sat down with me over a year ago to dig into the business. We called on various printers. And over a desk littered with magazines and papers we were led into a bewildering jungle of type faces, bindings, cuts, screens, and a multitude of strange terms that overrun the printing trade. But as we dug into the details and finally heard the cost quoted, we had to back down. The infant C.A.I., which then boasted only a scattering of members and sustaining members, was just not financially strong enough to embark on a printed Journal.

As a cheaper alternative, however, we drifted into investigating off-set reproduction. Thus the C.A.I. Log was born. We feel that from last September, until now, the Log has definitely filled a void. It has given all of us a chance to ponder over technical talks given in Montreal, Toronto, and Ottawa, at our leisure: it has passed us some of the day to day happenings at C.A.I. Headquarters as the organization has built up: it has provided us with an open forum for the exchange of ideas. But the "off-set reproduction" process of printing fails to reflect the true calibre of our organization. For, rightly or wrongly, we are judged by the English-speaking world at large, by the format of the publication we turn out. And there is no substitute, by modern standards, for the properly printed text.

However, as we all know, there is more to aeronautical technology than mere type face. The CANADIAN AERONAUTICAL JOURNAL is the technical voice of Canadian aviation. And as such we must continue to bring forth our worthy ideas, factual reports, informative data, research results. With these, as our Journal goes out to libraries all over the world, we will enhance our aeronautical reputation. But better still, we will learn from our fellow engineers and technicians. And as we learn we will design, build, repair and maintain to a higher standard than ever before.

Our Journals, then, will be building blocks of progress. For there is no greater force than the exchange of ideas, through the power of print.

GROUP CAPTAIN H. R. FOOTTIT.
Chairman, Publications Committee.

NEW RESEARCH FACILITIES FOR THE NATIONAL AERONAUTICAL ESTABLISHMENT IN CANADA

It was announced on April 6, 1955, that a new high speed wind tunnel installation is to be constructed at Uplands Airport in order to augment the aeronautical research facilities within the N.A.E.

Designs for the tunnel are now being completed and construction will begin during the summer. Installation will take about three years. To be housed near the flight research section, the tunnel will cost $3,500,000.

The tunnel will have a 5 foot square working section and a Mach number range from 0.2 to 4.5, including the transonic region. It will be of the intermittent type, blowing down from air storage at 20 atmospheres to atmosphere.

N.A.E. was created in 1951 to provide facilities adequate to meet the needs of the expanding R.C.A.F. At present the establishment comprises several small research wind tunnels and engine, structures and thermodynamics laboratories all at the National Research Council's Montreal Road site in Ottawa. It also includes the flight research section, which in 1953 moved from Arnprior to Uplands Airport and occupied a large hangar financed by the Defence Research Board.

Because of its lengthy experience in the field of aviation and allied research, the N.R.C. has operated the entire establishment during its evolutionary phases. When the Uplands' facilities become more self-sufficient with installation of the new wind tunnel, they will be separated from the National Research Council's Montreal Road elements and operated as a Defence Research laboratory.

Those on the Montreal Road will remain with N.R.C. where fundamental aeronautical research, both for military and civil purposes, will be stressed. The scientists at both sites will continue to work closely together however, to fulfill military and civil requirements.

Until the two sections separate, N.A.E. will continue its operations under J. H. Parkin who is also Director of the N.R.C. Mechanical Engineering Division.

The National Aeronautical Research Committee, which provides policy and development guidance for the N.A.E., will continue to act in an advisory capacity following the separation of the two sections.

INDEX OF THE C.A.I. LOG

To provide continuity the following is a list of papers and articles appearing in the C.A.I. Log which preceded the introduction of the Canadian Aeronautical Journal.

CORREGENDUM

Mr. Irbitis has pointed out an error in his article on the Wing-Sail in the March issue of the C.A.I. Log. He states that the maximum rotation of the wing-sail on his model was approximately $\pm$ 100° and not $\pm$ 200°.

SCIENCE AND DEFENCE†

by Dr. J. J. Green*

Defence Research Board

No one can foresee how history will judge this century but it is not too difficult to put down on paper some of the things for which we shall be remembered. Among the more important of these the men and women of the future will, I am sure, record that our generations were the first to apply science to warfare on an organized basis.

Man's earliest occupation seems to have been concerned with killing his fellow man and throughout the centuries of recorded history he has continued to wage battle, yet in all that time, until World War I, the character and strategy of war changed only very slowly.

If warfare is old so too is science. Its origins go back, no doubt, as far as the origins of warfare and we have evidence throughout history that man has in a limited way applied his science to warfare. It was in World War I, however, that man for the first time began to comprehend in a vague way that science could change the art of war. For in this conflict science had provided man with the internal combustion engine with which he powered the aeroplane, the submarine, the tank—three new weapons of great potential effectiveness. Science also gave him poison gas, radio communication and the machine gun.

WORLD WARS I AND II

It was during World War I that the Great Powers turned their attention to scientific research to aid the war effort. Great Britain created a Scientific and Industrial Research Committee and for the special encouragement of military aviation it established the Aeronautical Research Committee. Here in the United States at that time the National Advisory Committee for Aeronautics came into being for the same purpose and other organizations were created to foster research in other fields of science and engineering. With the coming of peace, these scientific organizations continued to exist at public expense and great value derived from the industrial application of the results of their work.

When World War II struck, the accumulated capital of scientific knowledge was applied immediately to the war effort and, in addition, the Great Powers took prompt steps to organize their scientific research more thoroughly in order to speed it up and to cut down the hiatus that always exists between research, development and production. Here in the United States in 1940 the National Defence Research Committee was established "to co-ordinate, supervise and conduct scientific research on the problems underlying the development, production and use of mechanisms and devices of warfare". Aircraft were excluded since the NACA was responsible for aeronautics.

World War II opened with the armoured tank and the dive-bomber which brought a new type of warfare characterized by speed of manoeuvre and the rapid conquest of large areas. At sea the magnetic mine appeared. On the defensive side the radar chain was ready and waiting for the attack. These and many other developments, including the German V-weapons, were examples of the powerful influence which science could have on warfare. The atomic bomb which rang down the curtain on World War II was, without question, the most spectacular reminder of these potentialities.

POSTWAR PROBLEMS

In much the same way that scientific research and development were continued after World War I scientific research and development specifically aimed at defence problems were continued after World War II. It was recognized that for better or worse warfare was now wedded to science and if nations are to survive they must strive to be pre-eminent in the application of science to defence. But a number of problems have arisen since the war to beset our efforts to attain close collaboration between the scientist and the military man.

Under the stress of war, men become united when all are working for the common cause. Sympathy and understanding are more prevalent than mistrust and suspicion. In the last war the scientist and the soldier met in committee and came to know and understand each other. Since the war there has been an urgent national need to bring science and defence into a much closer union. There is no denying that scientists are different from soldiers. The soldier is a man of action, aggressive and direct. The scientist is a thinker, only one step removed from the philosopher. The soldier is suspicious

† Luncheon address delivered on the 26th January 1955 at the Annual Meeting of the Institute of the Aeronautical Sciences in New York.

* Chief of Division "B", Defence Research Board, President of the Canadian Aeronautical Institute.

of all foreigners, particularly if they are civilians. The scientist is interested in scientific progress in other countries and is at his best at international scientific meetings and discussions. He has traditionally, whenever possible, corresponded with scientists in other countries who are working in the same field as himself in order to discuss related approaches to similar problems. Such exchanges have been enormously fruitful and in many cases the real key to progress. The scientist stays put in his laboratory, when he isn't at international conventions. The soldier is always on the move from posting to posting. The soldier gets promoted. The scientist doesn't get promoted as often. The soldier believes in security as a military necessity. The scientist in general thinks security is fine for military things but has grave doubts about classifying scientific discoveries. The soldier is trained to a military discipline. The scientist works in an organization in which he is responsible to his superior, but it is not a military discipline. Above all the scientist likes to have a superior who is a scientist also, whom he understands and can respect. It irks him if he is controlled and directed by a soldier, who may not understand his work and his outlook and cannot therefore encourage him to do his best and who may be posted away at any day to be replaced by another soldier who may be better but might conceivably be far worse than the first.

Many of the best scientists are not desirous of working in defence fields in the face of such problems as I have touched on. This is most serious because the survival of the free world depends more than ever on the struggle for technical leadership in defence matters and we can do our best only when we attract and utilize our best brains.

In Canada during World War II the burden of science for defence was carried by the National Research Council, the laboratories of which were devoted to war problems. The N.R.C. also undertook the organization and mobilization of the research talent of the country. At the end of the war Canada was faced with difficult problems in scientific research policy. The National Research Council wished to return to the fruitful paths of pure scientific research and peace-time industrial research. At the same time Canada foresaw the need for a permanent scientific group working exclusively on defence problems in support of the three Armed Services. The difficulties which might face such a group I have already mentioned. They were well appreciated and understood and had been discussed with men like Vannevar Bush in the United States and Sir Henry Tizard in the United Kingdom. I would like to tell you how Canada faced up to these problems.

DEFENCE RESEARCH BOARD

On April the first, 1947, the Government created the Defence Research Board as an integral part of the Department of National Defence to be responsible for research relating to the defence of Canada and for advice to the Minister of National Defence on all matters relating to scientific, technical and other research and development that might affect national defence. The Chairman of the Board, Dr. O. M. Solandt, an outstanding Canadian scientist with a distinguished war record in defence science, was appointed to head the new organization and was made a full member of the Chiefs of Staff Committee. The Board itself is a unique experiment in co-operation between civilian scientists and the Armed Services. The three Chiefs of Staff of the Navy, Army and Air Force are members of the Board along with the Deputy Minister of National Defence, corresponding to your Assistant Secretary of Defence, and the President of the National Research Council. The Deputy Minister of the Department of Defence Production is also a member. There are in addition some six or seven members chosen to represent science and industry throughout Canada. These latter appointments, however, are for a three-year term only. The Board, which meets about once every three months, is responsible for approval of policy.

The Board has a scientific staff known as the Defence Scientific Service. In Ottawa, a headquarters staff is housed in the same building as the headquarters staff of the three Armed Services and is the main link between them and the Defence Scientific Service which has become, in effect, Canada's fourth Service.

LABORATORIES AND ESTABLISHMENTS

The headquarters staff, in addition to providing scientific advice and assistance to the Armed Services, is responsible for administering a number of research and development establishments scattered across Canada. We operate two naval research laboratories, one on the Atlantic Coast and one on the Pacific. Since the Royal Canadian Navy is concerned mainly with submarine detection and destruction, the work of these two laboratories provides support to this role. Because of the very peculiar water conditions that exist on the Canadian Coasts it is extremely difficult to detect submarines. Our naval laboratories have been able to initiate some very promising developments which we hope will overcome this difficulty. Excellent work has also been done on developing anodic methods for the protection of ships' hulls against corrosion.

Near Quebec City the Defence Scientific Service has an Armament Research and Development Establishment. Here we are at the present time developing an air-to-air guided missile for the Royal Canadian Air Force. I am pleased to say that in this effort we are indebted to the United States for assistance in the way of information exchange and the purchase of components developed in this country. This armament establishment has already made very considerable contributions to the Free World. It was here that sabot ammunition for the 25-pounder and the 76 millimetre gun was developed. This ammunition has been adopted as standard by Canada, Great Britain and the United States. Believe me, Gentlemen, any time you can sell something to the United States you can be sure it is good. This establishment has also developed an infantry anti-tank weapon of the bazooka type, with heavy striking power and an accuracy which approaches that of a gun. One of its earlier efforts was the design of a pack howitzer which was capable of being quickly dismantled into small parts suitable for mule or air transport. The American Marine Corps was extremely interested in this project.

At Kingston, Ontario, we have a small laboratory which concerns itself with the defensive aspects of bacteriological warfare.

In Ottawa, the Capital City, we have a number of laboratories. A telecommunications establishment has done important research on the influence of the aurora borealis on radio communication. This same establishment was largely responsible for development of the equipment for the mid-Canada warning line, referred to earlier as the McGill Fence.

Our Defence Research Chemical Laboratory is also situated in Ottawa and has in the past been largely concerned with the defensive aspects of chemical warfare, and more recently with the defensive aspects of atomic warfare.

We also have in Ottawa our Operational Research Group which is working exclusively for the three Armed Services.

In Toronto, we operate a medical laboratory devoted to the physiological problems of man in a military environment, including aviation medicine problems. Work of an important nature leading to a number of discoveries and developments has been done here. In the subject of motion sickness advances have been made in our understanding and control of this affliction. Important studies of the influence of cold on human joints has led to significant results. Good work has been done to assist the aircraft designer in such tasks as the layout of the navigator's compartment on long-range aircraft in order to achieve the maximum efficiency and convenience. The food section of this laboratory has been concerned with in-flight feeding for air crew and the development of special ration packs for arctic use and for use in other isolated locations.

At Churchill we have a northern laboratory devoted to the problems of man in the Arctic.

Finally, in southern Alberta we operate an experimental station having some 1600 square miles for chemical warfare field trials. The facilities are used extensively by the United States Chemical Corps and to some extent by the United Kingdom. There is no time of the year when either American scientists or American Service personnel are not there, and the relations between your people and ours are very cordial indeed.

To a lesser extent American scientists also use the facilities of our Arctic laboratory at Churchill.

In addition to the use of our own establishments we are utilizing more and more, and whenever possible, the services of other laboratories—government, industrial and university for research and development on defence matters. As examples, we look to the National Aeronautical Establishment, which is operated by the National Research Council, to handle many of our aeronautical problems. The N.R.C. also assumes for us much of our radar work and this is carried out in their Division of Radio and Electrical Engineering. When initiating metallurgical developments or research, we turn to the Mines Branch of the Government for assistance.

The Board has also provided funds to set up basic scientific research laboratories in some of the universities, for work in fields of special interest to defence. As examples, I can quote the Institute of Aerophysics at Toronto University and the Eaton Electronics Laboratory at McGill University in Montreal. First-class work is being done in both of these places.

CO-OPERATION AND EFFICIENCY

Ever since its creation the Defence Research Board has attempted to adhere to a firm policy not to engage in research and development covering the entire defence field. We believed it much more important to do those things that friendly nations expected of us, and do them well, than to expend our limited funds and manpower on a large number of projects. We have, therefore, done those things for which we are most suited either by geography or national resources, or for which we have unique requirements not duplicated in the United States or Great Britain. It is recognized that we can adopt this policy only because the United States and Great Britain are willing to give us the results of their work in other fields. We have shared our information and results with these two countries and I would like to say how fortunate we are in Canada that we enjoy the trust of both countries and have received, in return for what we have contributed to the common cause, information important to our defence about matters on which we have been unable to engage ourselves.

Because of our limited manpower and funds, we have been forced to use them both efficiently and this has been most beneficial to us. We can never be prodigal with either and we are, in Canada, proud of the achievements we have had with so limited an effort. We have never had any dearth of ideas, and it is ideas that spark research. In approaching a new problem we cannot afford to expend effort on all possible avenues of solution. We must ponder at length and decide finally which course will lead to the solution.

Now that we have, as it were, provided the basic facilities for research and development in our establishments and in those laboratories which have allied themselves with the needs of defence, we are giving more attention to the fundamental needs of the Armed Services. Science changed the character of war in the last conflict, but scientific developments since the war have promised even more drastic changes. In such a world as we now have, the roles of the Armed Services in a future conflict, with the possible exception of the Air Forces, have become somewhat changed and cannot be explicitly defined. Planning for defence has been rendered enormously more difficult and cannot be done expertly without sound scientific advice and the collaboration of scientists. In Canada, the unique position of the Defence Scientific Service, as a full working partner of the Armed Services within the Defence Department, enables us to play a valuable part in defence planning whether this involves the development of new weapons and equipment or the philosophy behind the employment of military strength in a future conflict.

We have gathered together an organization of scientists and engineers devoted to the needs of the Armed Services. We are attracting the very best of our graduates. We have built up a spirit among our staff which is based on understanding and respect for the military man and his problems. We have had our difficulties but these are rapidly decreasing. I believe that we have won the confidence of the Armed Services and they know that the measure of our own success can only be taken by their satisfaction with us. We are well on the way

to providing that close integration of science and defence which is essential for survival.

I referred earlier to the fact that in many fields of endeavour we in Canada enjoy a close co-operation with the United States. I hope and believe that this will continue and will expand. It is important for our survival. I believe that this spirit of closer co-operation must extend to the other countries with which we are friendly, and particularly to the NATO countries. In aeronautics the fine leadership given by Dr. Theodore von Kármán in fostering this co-operation, through AGARD, stands as a shining example to us in a world full of doubts.

This audience needs no reminder of the time it takes in the Western World to bring new developments to fruition. Coupled with this fact is the knowledge that our efforts must cover all possible threats to our security. A potential aggressor can choose his own time and methods and can limit his objectives. Recent Russian advances in atomic weapon development and in the design and construction of long-range bombers powered, no doubt, with engines of large thrust show what can be done when effort is channelled into a narrow front and emphasize the closeness of the competition for technical leadership.

If the West is to survive we must solve the problems of the relations between science and defence and we must maintain and strengthen the collaboration between the Western nations in all matters, but particularly in those which concern science for defence.

R O R

For vertical lift and load-carrying capability at high altitudes, the modern helicopter requires a far greater amount of power than it does for normal cruising operations. To compensate for these short-comings helicopter designers have adopted the fixed-wing assisted take-off principles, as exemplified by JATO, and produced a power boost system which provides for extra power for relatively short periods. This auxiliary boost system was developed by Reaction Motors Inc., Rockaway, New Jersey under contract from the U.S. Navy and is nicknamed R O R for rocket-on-rotor.

The R O R system consists of small rocket engines mounted on the tip of each rotor blade. The rocket engines operate on hydrogen peroxide which is fed to the engine from a hub-mounted propellant tank. A typical engine installation is shown in Figure 1, while Figure 2 illustrates the ancillary propellant tank and control system layout.

Figure 1

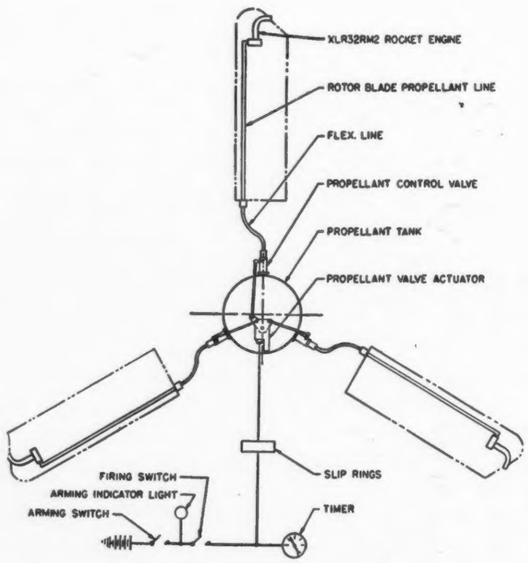

Figure 2

An R O R installation for a 3-bladed rotor weighs approximately 67 pounds dry and produces a total thrust in the order of 120 pounds. It is estimated that to provide a comparable increase in power through the installation of a larger main reciprocating engine, the engine itself would weigh approximately 200 pounds more. In addition the entire transmission system would have to be considerably strengthened to transmit the additional power.

The dome shaped tank contains 300 pounds of propellant, enough for six minutes of operation. R O R may be employed during take-off, hovering and autorotation periods. The auxiliary boost produces an additional lifting force in the order of 20%, which in effect doubles the take-off payload of the helicopter. Once underway with forward speed the rotors create adequate lift to sustain flight conditions for the greatly increased load. Additionally R O R provides considerably improved glide performance and control in the advent of prime engine failure as well as greatly improved rate of climb and hovering ceiling.

PREREQUISITES FOR AIRCRAFT PRODUCTION†

by R. A. Neale*

Canadair Ltd.

FROM 1939 through 1945, the aircraft industry in Canada produced to the value of 965 million dollars. This expenditure included the production of aircraft as well as overhaul and repair. During this time 16,418 aircraft were built, of which 9,950 were exported. The industry grew from 8 plants with 500,000 square feet and 4,000 employees to 45 plants with 15,000,000 square feet and 116,000 employees. In 1948, the total number of aircraft plants had dropped to 11, employing 8,049 people.

Today, the aircraft industry in Canada is producing at an annual rate of approximately 400 million dollars, or 2½ times the average of the six war years, and 1½ times the maximum year of 1944. Canadair, in 1953 alone, produced at a rate of 53% of Canada's total aircraft production in 1944.

We may allow for the decreased buying power of the dollar. Nevertheless, the foregoing data adds emphasis to the importance and predominance of aircraft and associated goods in defence plans and in other fields of usefulness. The better the results we obtain in respect of cost and quality, the more firmly the industry becomes established, the greater the value received by the customer for the dollars he spends, the more the taxpayer benefits since his tax dollars are spent by our principal customer and, finally, we best apply our efforts in the common fight against those endeavouring to overthrow free enterprise and free government.

"Prerequisites for Aircraft Production" appear logically to fall under four sub-headings, namely, Plans, Plant, Policy and People. Experience in the aircraft industry in no way differs from that of other enterprise in giving People position No. 1 as the most important factor of the four. Perhaps our industry, because of the high direct and indirect man-hour content in its product, makes this selection of the most important factor with less deliberation than do others.

The ever-changing conditions within the industry present many difficult and challenging problems. The sonic wall has been pierced—it is no longer an unknown—and flight exceeding the speed of sound has become routine. However, the obstacles presented by the thermal barrier and the vertical frontier still await complete conquest. Technically these problems have been, and will continue to be, conquered. Solutions will come about in the shortest possible time if there exists a spirit of co-operation among all the people involved.

1. PLANS

Plans will be discussed first because the natural sequence places them ahead of the other three factors. Plans alone, however, are insufficient and rely to a great extent upon Plant, Policy and People, and that is why each of these subjects is constantly intermingled with the one being discussed.

In treating of the subject, we will not deal with the very important functions of tool processing and design, production planning, material control planning, quality control planning and other planning functions throughout organization, which are, individually and collectively, essential to the end result. We will, however, develop a basic plan for the benefit of these previously mentioned functions which will provide them with vital statistics as to schedule time requirements, sequence requirements, quantity requirements, machine tool and equipment needs, man-hour cost requirements, and other guiding information and data.

Plans are subject to change and, therefore, must be as flexible as possible. This does not mean that an initial, detailed plan makes no allowance for an element of contingency, but the fact must be kept in mind that plans will have to be changed from time to time, depending upon variations within the factors involved.

The evolution of an aircraft from drawing board to first flight involves extensive planning which must be laid down in a detailed and orderly fashion, particularly when substantial quantities are contemplated. It is more than a general overall plan and includes, *first*, the determination of objective; *second*, the specifying of how, when, and by whom the plan is to be executed; and, *third*, the means of appraisal by management. In turn, these items must be broken down and planned in detail so as to cover all foreseeable problems. Again, although this plan is most minute in detail, it must also be very flexible so that it can be altered to fit current needs and will not preclude revision should difficulties occur in the future.

†Paper read before the Toronto Branch of the C.A.I. on the 25th January, 1955.

*Vice-President, Manufacturing.

During the course of its present ownership, the bulk of Canadair's production has been in aircraft designed by others. My most recent experiences stem, therefore, from manufacturing as a licensee.

The F-86 and T-33 aircraft we are building were, with certain exceptions, currently in production in the licensors' plants at the time production was initiated in Canada. The detail engineering design was therefore available, as were complete tool designs. In addition, it was possible to visit these plants and see the aircraft in all stages of production. Throughout the course of these programmes, the highest type of cooperation was received from both North American Aviation and the Lockheed companies. This method, however, was not without its distinct disadvantages. In both cases, production engineering was tailored to the equipment, processes and skills available in the designers' plants. Tooling created a problem, for it was designed for a different rate of production and for different equipment. Each license agreement requires the assimilation and integration of the licensor's practices and procedures into your own organization.

In addition to the foregoing, major power plant revisions have been introduced. In the Sabre the Avro Orenda engine replaced the General Electric J-47, and in the T-33 trainer the Rolls-Royce Nene replaced the Allison J-33 engine.

It will be appreciated that changes of such magnitude present major problems, when introduced into expedited production programmes.

To get back to the plan—it is important to note that it does not emerge as a fixed, static plan from its inception, but rather evolves through a series of stages, each of which contributes to its detail and scope.

One of the predominant characteristics of aircraft production is change; much as all concerned would like to "freeze design", such a thing is practically unheard of and, consequently, a static or fixed plan is seldom realized; therefore, an important factor of the plan must be its flexibility.

Speaking of changes, it is normal to associate their origin with the engineer, particularly when we propose to "freeze a design" to arrest change traffic. At such a time, feelings have been known to run high. On one such occasion it was suggested that if all the engineers concerned were laid end to end it wouldn't be a bad idea; or, if laid end to end they couldn't reach a decision.

This suggestion is, in my opinion, undue and unjust—only *some* of them should be laid end to end. On the other hand, from an accountant's viewpoint the engineer rates amongst the lowest of humans—the typical engineer is visualized as a full-blooded enthusiast, a cigar smoker with hair on his chest and a YMCA secretary's smile. He talks in astronomical figures and abhors detail. His limit of accuracy is plus or minus $5,000 and he brags if he stays within these limits. He is the despair of auditors, exceeded in this respect only by social workers. Happily, he is a mule without pride of ancestry or hope of posterity and goes to an early grave cheerily waving a slide rule, mourned by none and remembered only by his creditors.

I could also give you an accountant, from an engineer's viewpoint!

At present, there is not enough time to go into all the detailed mechanics of the planning, but to illustrate the overall scope of this function, some of the tools utilized are described. Chart terminology may be foreign to you, but it is hoped that in conjunction with figures shown, you will be able to identify them with their counterparts at your respective organizations.

The programme plan actually starts with the fixing of (1) date of first delivery (2) peak production rate and, (3) acceleration to peak rate.

A consideration of the first usually starts with an attempt to answer either of two questions stemming directly from the customer—"We would like an aeroplane on such-and-such date—can you do it?" or "How soon can you give us an aeroplane?" The problem posed is to visualize as accurately as possible what must take place between this initial time and any contemplated delivery date. In general, several distinct operations must be carried out and a block of time must be allocated for each, sufficient to assure completion. Thus, a chart similar to Figure 1 is drafted in which engineering, planning, tooling and production elapsed times are related. The time allowed for these processes is strictly a function of past performance modified to conform to the terms and conditions anticipated for the proposed programme. Past performance, as illustrated here, shows one thing definitely—no two programmes are exactly alike.

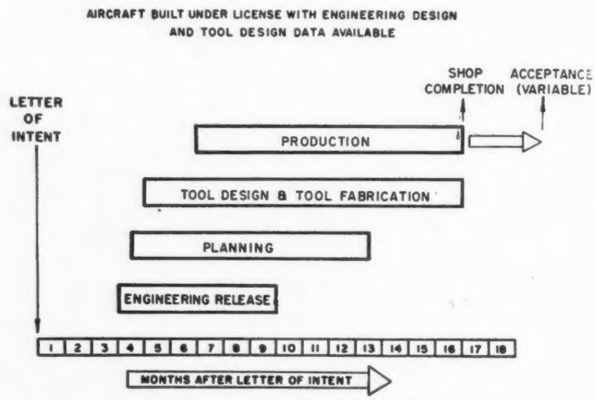

Figure 1. Typical production set back time.

Figure 2 illustrates the spread in total elapsed times resulting from definition of programme. When a given category of aircraft is studied within a reasonable weight range, the size of the aircraft has little bearing on establishing the overall elapsed time. Principal governing factors are type of aircraft, degree of complexity of structure, systems and installations, and capacity of organization and facility.

Time is a prime consideration in producing aircraft, since the customer or your Sales Division invariably requires them yesterday.

Once decided upon, whether the aircraft are for civil use or for military use, they do not "pay off" until they are in the hands of those who are to fly them.

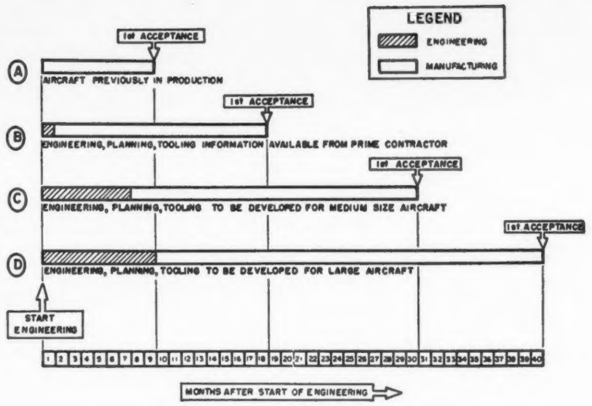

Figure 2. Range of first aircraft flow times.

So, with this incentive coupled with our block flow times, we can move on to the preparation of a preliminary master schedule, as per Figure 3.

The purpose here will be to determine a fix for a shop completion, acceptance or delivery date for the first aircraft of the series. You will note that this schedule basically establishes subdivisions within the manufacturing block flow time related to the engineering block.

Since a high degree of obsolescence is associated with the product, the requirement usually follows the pattern of delivering the maximum number of units in the shortest possible time at minimum cost and maximum quality. That's quite a trick! This sort of situation may be classed as one reason for the saying, "A person doesn't *have* to be crazy to be in the aircraft business—but it helps."

Next, the peak production rate must be established. The customer may decide this, based upon his ability to utilize the aircraft in his operation. A consideration in setting rate, gained from our past experience, is that the monthly peak rate should not exceed 10% of the total

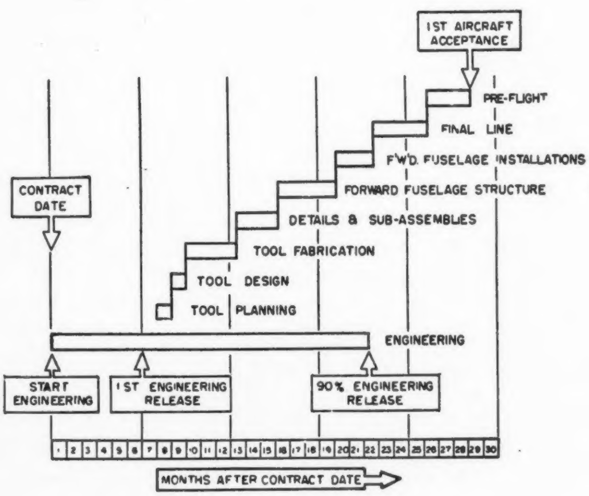

Figure 3. Preliminary master schedule.

number of aircraft involved; that is, for a quantity of 300, the maximum rate would be 30. This limitation will assist in minimizing of manpower peak and need for multiple tooling. Another factor in relation to the setting of rate, worthy of consideration, is whether to produce at a *constant rate*, which will call for continual reduction in manpower applied, or to hold *manpower* constant, and to allow the production rate to increase during the course of the programme. I will make reference to this matter at a later point, in dealing with manpower forecast. Assuming rate has now been named, the acceleration from completion of the first unit to planned rate must be determined.

There is a good deal of historical data available on acceleration rates and we are indebted to Mr. P. J. Stanley of the College of Aeronautics, Cranfield, England, for excellent work in this field.

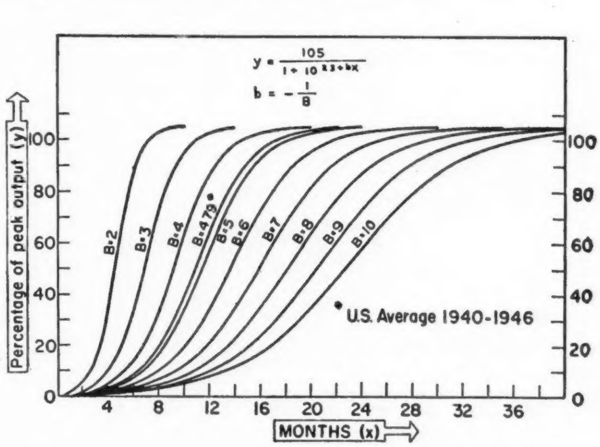

Figure 4. Peak output curves.

Through analyzing data of World War II production experience in the United States, Great Britain, Germany and Japan, Mr. Stanley determined that the acceleration rate of all aircraft production programmes follows a definite pattern, and that a logistics curve fits the actual historical data available with considerable accuracy. In addition, he has established that this pattern is for all practical purposes independent of the size of the aircraft or the production programme, and is more a function of facility, management skill and basic design of the aircraft.

Mr. Stanley developed a group of curves in accordance with Figure 4, covering the range of variation in acceleration in the various programmes analyzed. These curves are identified by a "B" index of steepness and are expressed on a time basis. Figure 5 shows a curve fitted to the data of actual performance from a particular programme. Figure 6 indicates typical schedule acceleration calculations for both "B2" and "B5" curves.

We have used this method with considerable success and by applying modifications based upon our past performance, can confidently plan an acceleration which is attainable.

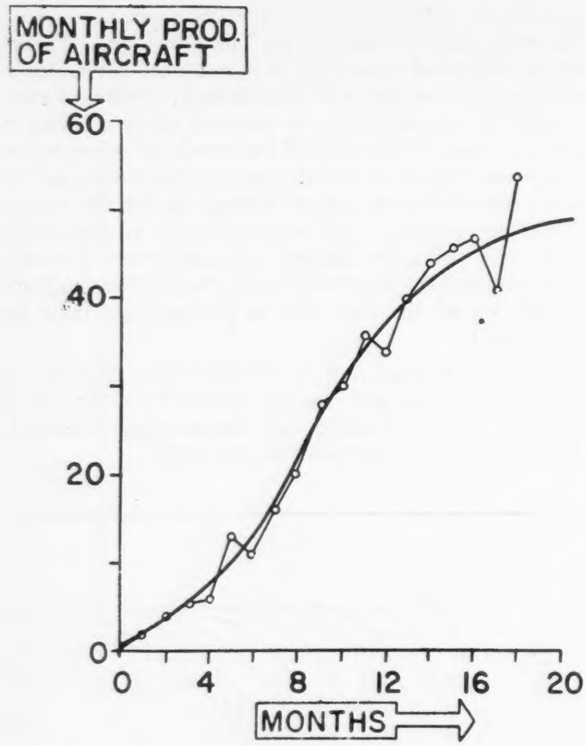

Figure 5. Production data with fitted logistic curve.

SCHEDULE ACCELERATION CALCULATIONS FOR MAXIMUM RATE OF 50 A/C PER MO.

MONTH	B-2 % MAX. RATE	B-2 SCHEDULED A/C / MO.	B-5 % MAX. RATE	B-5 SCHEDULED A/C / MO.
1	1.64	0.8	0.83	0.4
2	5.04	2.5	1.31	0.7
3	14.39	7.2	2.06	1.0
4	35 10	17.6	3 22	1.6
5	64.40	32.2	5.00	2.5
6	87.60	43.8	7.72	3.9
7	98.70	49.4	11.78	5.9
8	103.00	51.5	17.50	8.9
9			25.25	12.6
10			35.10	17.6
11			46.50	23.3
12			58.50	29.3
13			69.90	35.0
14			75.80	39.9
15			87.50	43.8
16			93.40	46.7
17			97.70	48.9
18			100.00	50.0

Figure 6

We have now completed our preliminary master plan which

a) specifies a delivery date for the first aircraft;

b) establishes the acceleration or build-up from that point to peak rate; and

c) maintains peak rate or a scheduled rate to the end of the contract.

The foregoing has now set an outline which gives pattern and pace to direct our thinking in the subsequent phases of detail planning.

Our efforts, to date, have proceeded without benefit of much engineering detail, assuming the project involves initial design. In this case, planning will largely be paced by such design creation and release. In the event an aircraft is built under license, engineering information generally is available for detail planning purposes in a much shorter span of time.

Upon release of the information in either case, our problem in manufacturing is that of integrating major assemblies, sub-assemblies, fabricated parts, purchased parts and supplied parts so as to produce aircraft at specified times and rates.

The first consideration in our detail planning will be to establish the assembly breakdown and the number of work positions required to build the aircraft at the planned rate. The engineering design specifies, or can permit, certain basic splits or joints in structure so that, from the manufacturing viewpoint, the best possible component arrangement results. Further breakdown within the individual component, so established, may be accomplished during the course of manufacturing planning.

Figure 7 illustrates this in the case of a twin-engined aircraft, and Figure 8 in respect of a larger aircraft. The rate and quantity of production will probably influence the extent of the breakdown more than any other factor.

The prime objective in establishing the breakdown and work positions will be to divide the aircraft assembly

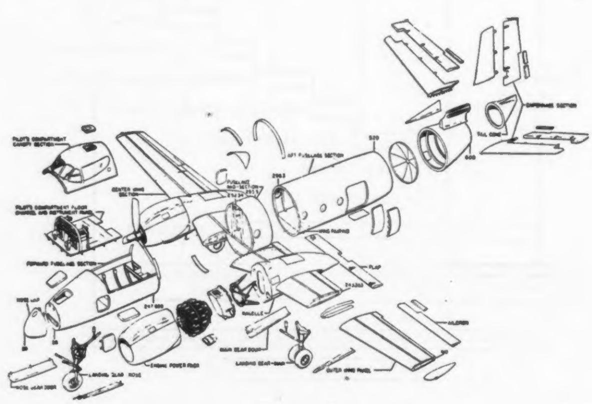

Figure 7

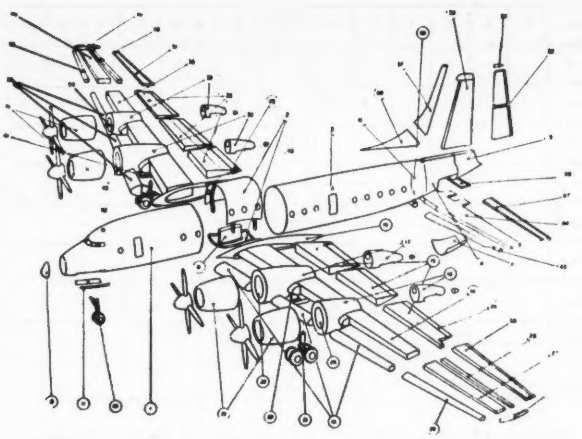

Figure 8

operations in such a manner that the maximum number of men can be applied concurrently to the aircraft in the form of its component parts. This will reduce the assembly flow time, since it is governed by rate of man-hour expenditure. Additionally, the objective will be to expend as many hours as possible *early* in the manufacturing assembly process, so that a minimum of work is left to be accomplished at later stages when the aircraft is completely assembled, at which time working space and accessibility are limited.

Following establishment of the breakdown, our next requirement will be to calculate the number of work positions, which will control the number of major components and complete aeroplanes in our assembly process.

First, the man-hours required to build the number one unit of each major assembly or installation is

1. POUNDS OF AIRFRAME WEIGHT PER UNIT,
   X MANHOURS PER POUND
   = No. I UNIT MANHOURS

2. No. I UNIT MANHOURS (1),
   X LEARNING FACTOR FOR Ist. UNIT AT PEAK RATE,
   X PEAK RATE PER DAY
   = MAXIMUM MANHOURS PER DAY AT PEAK RATE

3. WORK LENGTH OF UNIT,
   X .20 MEN PER LINEAR FOOT,
   X HOURS PER SHIFT,
   X SHIFTS PER DAY
   = MANHOURS APPLIED PER POSITION PER DAY

4. MAXIMUM MANHOURS PER DAY, (2)
   ÷ MANHOURS PER POSITION (3)
   = WORKING POSITIONS REQUIRED

Figure 9. Calculation of the number of working positions required.

estimated. We then assume a learning rate for each such operation. Using this rate, we calculate the hours to be expended per day to produce the assembly or unit of work at the planned peak rate of production. By then estimating the number of men that can be efficiently applied to work at one time, on the unit or assembly in question, the number of work positions can be calculated.

Figure 9 illustrates rather simply this complicated sounding manipulation.

Having now an assembly breakdown, together with required work positions, we consolidate this data into an assembly and installation position chart, thus establishing sequence of assembly.

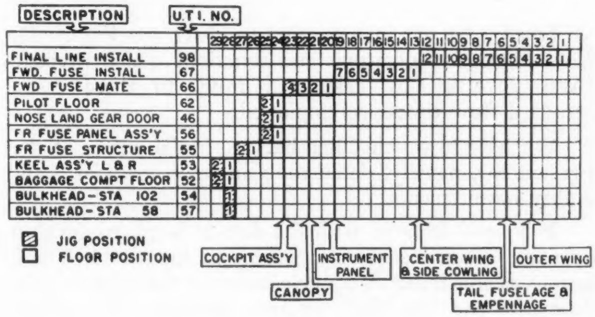

Figure 10. Position chart assembly and installation.

Figure 10 shows the component, sequence and work positions required to build each component. Each component and each work position is identified by code number. These numbers provide the means of specifying on all subsequent planning paperwork the usage point on major assemblies of all tools, purchased parts, fabricated parts and sub-assemblies, additionally, these unit and position codes assist in scheduling and control, since usage point may be related to requirement date.

Master schedules can now be drafted for the first unit of each major assembly.

Figure 11 shows a typical presentation of a fighter component. There will be from 75 to 100 such schedules drafted on the average small fighter or transport aircraft.

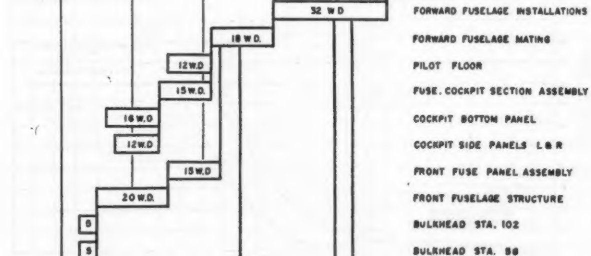

Figure 11. No. 1 unit detail master schedule forward fuselage.

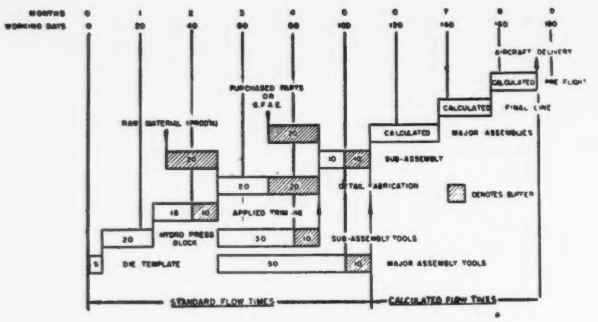

Figure 12. Master schedule plan.

Finally, we are in a position to chart, per Figure 12, flow times for operations and functions which precede items governed by calculated flow. In these cases, standard flow times are employed.

We have now scheduled back to initial phases of the programme, namely, detail tools and raw material availability requirements.

It is possible now, with the data at hand, to develop schedule control curves, as shown in Figure 13. These curves establish the time cycle between the start of subassembly for the first aircraft through the various assembly stages to completion of the first aircraft. Similar cycles for each subsequent unit in the entire quantity can be taken from these curves. This data provides us with a multitude of requirement dates governing all units and all operations involved in the overall assembly function, since it has been derived from the previously drafted master schedules for each major assembly and their required work positions. Later in the planning, this data will be used in determining man-hour expenditure distribution.

Raw material and purchased parts are scheduled for availability in a similar manner, except that lead time is established in relation to the aircraft schedule. This is shown in Figure 14.

Major purchased equipment and government-supplied materials are scheduled on a calculated basis, as required by usage point.

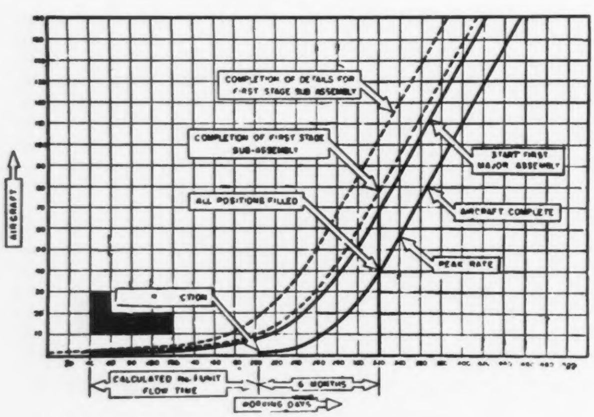

Figure 13. Schedule control curves.

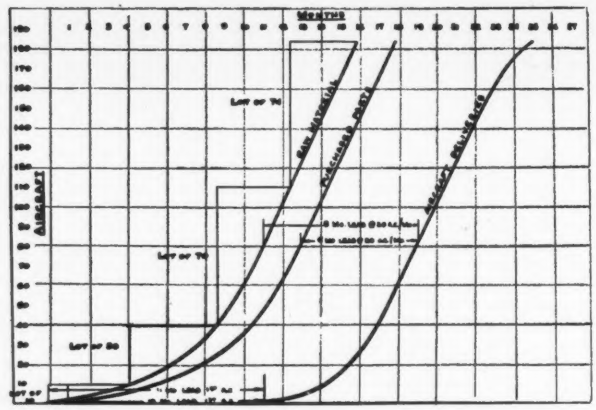

Figure 14. Raw material and purchased parts schedule.

Individual tool fabrication orders and production shop orders all bear a code number indicating requirement for completion.

Based upon data developed up to this point, the need to forecast direct manpower requirements becomes necessary. This phase of planning is subject to constant revision and we class it as one of our most difficult planning operations. The difficulty encountered stems from the great number of highly variable factors to be considered. Manpower forecasting is based on a target aircraft; this may be the first, tenth, twentieth or the one hundredth unit within a series. The estimate is the usual one based on aircraft weight, number of engineering drawings and analysis of complexity, equipment, test programme, type of tooling and any other complicating factors. In going from the estimated man-hours for the selected unit to the complete estimate, the usual learning curves are employed. Different curves are selected for different types of work, as previously mentioned, and are combined to give a composite overall curve. Figure 15 represents a set of typical curves.

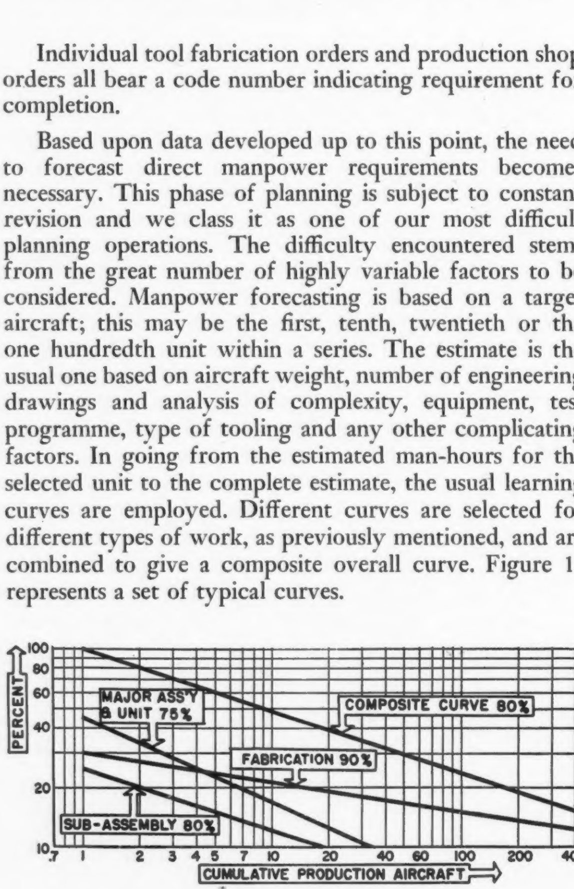

Figure 15. Types of labour unit learning curves.

Canadair accepts the theory of the learning curve as first stated in 1936 by Dr. T. P. Wright, Vice-President for Research, Cornell University, and as validated by the experience of the industry during World War II.

Various expressions have been applied, such as cost reduction curve, experience factor, improvement trend and time reduction curve, but in this discussion we will hold to the term "learning".

The mathematical implication of the learning theory is that a constant percent increase in the cumulative aircraft number is accompanied by a constant percent decrease in unit man-hours required. For example, if the overall learning curve is 80%, the 2nd unit will cost 80% of the first, the 4th 80% of the second, the 8th 80% of the fourth, and so on. Thus, as the quantity doubles, a constant reduction of 20% in hours occurs. In accepting this theory, the benefit derived may be realized in either of two ways:

a) When manpower is held constant, output of product must be on a continually increasing basis, or

b) When a constant rate of output is maintained, manpower must be progressively reduced.

Canadian production of the F-86 and T-33 has generally been governed by constant rates and therefore the problem has been the extremely difficult one, as stated previously, of constantly reducing the applied manpower to secure progressively lower unit costs. Under emergency conditions, accepting of an increase in the output of product is attractive because more aircraft can be produced with the same work force and facility.

Now, with man-hour requirements established, the distribution of man-hour expenditure is calculated for the programme. A series of ogives are drawn for:

a) tool fabrication hours, based on calculated flow times and hours;

b) fabrication hours, based on standard flow times and standard allowed hours;

c) sub-assembly hours, based on standard flow times and a combination of standard allowed and calculated hours, and

d) major assembly hours, based on calculated time cycles and calculated hours.

A typical ogive or reverse curve is shown in Figure 16, expressed in terms of percent man-hours and percent time cycle. The shape of the ogive is influenced by the time cycle, the various learning curves, lot or batch sizes and, finally, by comparison with data on past performance within the company and within industry.

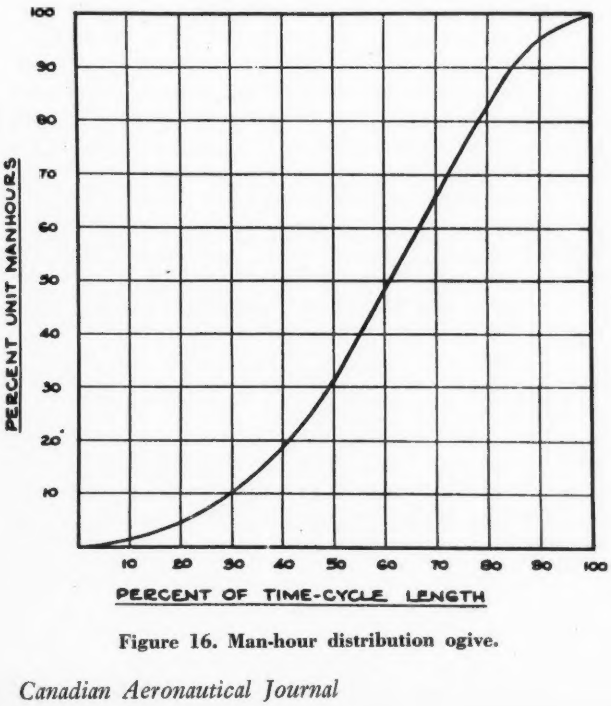

Figure 16. Man-hour distribution ogive.

The ogive distribution data can now be consolidated and expressed in terms of a manpower forecast chart, as shown in Figure 17.

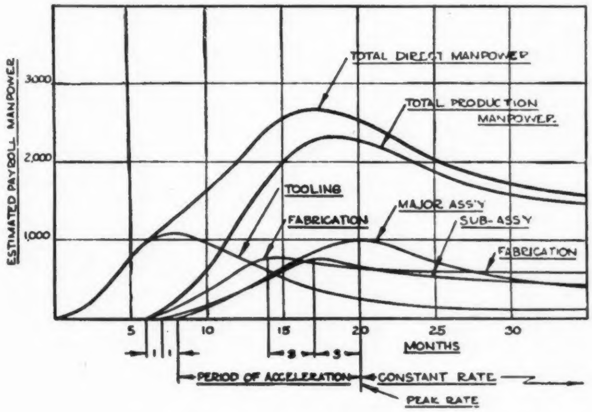

Figure 17. Manpower forecast chart.

The basic plan is now outlined, thus permitting the many other functions aforementioned to execute their responsibilities and activate the programme through procurement of materials, fabrication of tools, making of parts and providing of the multitude of things required.

As the programme advances, the succeeding inevitable alterations to the plan are dictated by the performance of the various divisions in our organization, changes in the objective, and inaccuracies in estimates. To evaluate these factors, a series of reports, charts and comparisons is prepared. These include records of direct man-hours expended against the budget; rate of tooling and processing release; rate of material procurement; records of scheduled plant-rearrangement; acquistion of additional plant facilities, machine tools, new equipment; and analysis of physical performance versus schedule requirement.

In the general nature of things, the actual performance often deviates from the planned performance. The reasons may be obvious or obscure and the amount of analysis required will vary accordingly. In any case, efforts are directed towards keeping a thoroughly realistic, detailed and up-to-date plan of each portion of the operation in the hands of supervision at all levels and in all departments, thus relating estimated with actual performance.

2. PLANT

Plant must be treated on a longer range basis because of the long lead times that are usually involved.

The planning of facilities is a continuing process and is carried on within the same overall framework of the processing and scheduling just described. A broad and general estimate of space required is made even before a contract is entered into and this is refined by stages

until line positions and number of jigs are determined. Machine tools, test equipment and other facilities are planned in a similar manner. The engineering department, tool planners, processors and all other departments which have an opportunity to observe the processes required by the design, are alerted to report any requirements which are outside the scope of existing facilities. They also watch for machine capacity requirements in critical machine tool categories, i.e., die sinking, profiling, jig boring, etc. Under usual conditions, an engineering department designs to utilize the equipment which exists in the plant, or if a new process is to be introduced, discusses the new requirements with factory management. In producing from the designs of others, however, rather unexpected requirements sometimes arise. Usually, these needs have been anticipated by a thorough inspection of all operations at the designer's plant.

In addition to determining requirements which stem directly from design, a constant survey for improvement of present methods and equipment utilization is maintained. This is also done for the purpose of comparing costs resulting from employment of existing methods and machines, with possible lowered cost obtainable through use of new machines, methods and equipment. Definition of costs in this instance embraces all elements with allowance made for amortization of capital investment.

In 1949, while completing production of North Star aircraft, Canadair utilized approximately one million six hundred thousand square feet of covered space, and employed 1,093 machine tools and major pieces of equipment at a total replacement value of about $6,000,000.00.

Since that time, the total area has expanded to a total today of 2,640,000 square feet, including buildings at present under construction. The machine tools and equipment now stand at 1,802 with a total replacement value of about $18,000,000.00.

These increases were not in all respects made to satisfy specific requirements generated by the several aircraft programmes. The trend of industry and the need to prepare for programmes and projects, not necessarily secured, but anticipated for the future, were dominant factors in determining plant expansion.

One sidelight of the various major building projects we have instituted may be of interest to you. Without exception, we have been so inept in our planning and demands for space that 90% of the total construction of buildings has been accomplished during our Quebec winters. As a result, on one occasion we had, in early June, the largest, most colossal ice box in Canada. This particular building was complete in all respects except for installation of a floor. The ground inside was frozen solid to an average depth of 2½ feet. Attempts by the contractors to thaw out this mess caused 85 to 90 degree temperatures inside, as compared to 70 to 75 degrees outside. The results, however, were pleasantly surprising.

Construction industry work volume drops off as cold weather approaches; contractors' pencils have a more pointed end; they want to keep their nucleus of organization together and, therefore, extremely low bids tendered by highly reputable firms have been obtained. We have reason to believe that construction costs during the winter months are often no higher than during the warmer seasons.

3. POLICY

Policy is not necessarily based upon technical knowledge. However, it behooves those who formulate policy to become familiar with the technical facts at hand.

Canadair has been fortunate under its present ownership, in that the lines of company operating and fiscal policy have been clearly defined. Furthermore, the policy of the Government toward the Canadian aviation industry has been consistent.

In an old-fashioned way, our corporate management has directed certain policy and set objectives toward realizing a goal at the end of the rainbow. We are fundamentalists in the belief that profit is not without honour from the standpoint of the going concern. Someone recently recalled a philosophy that it was sinful to make a profit. In this light, I guess we are simply willing sinners! There is an old North American Indian slogan alluding to profit, that we are guided by in a joking way—

> "Count that day lost whose low descending sun
> sees quotations made at cost and business done for fun."

Since we are endeavouring to confine remarks to aircraft production, no attempt will be made to deal more extensively with the matter of policy, beyond that required for operations.

Within the lines of broad government and corporate policy, the policy by which the manufacturing effort is conducted has been formulated, to a considerable degree, by a Manufacturing Management Committee composed of the Departmental Managers within the Manufacturing Division, and the Vice-President. Meetings of the Committee are held regularly each week. Depending upon topics listed for discussion, high-echelon personnel of the Engineering, Financial, Sales and Public Relations Divisions are often included as observers, thus effecting the desired degree of co-ordination throughout the company.

All meetings are based upon advance agenda, with subsequent distribution of extensive minutes to committee members as well as, for information purposes, to a wide listing of supervisory personnel in the various departments, and to the observers.

In turn, each Department Head holds a weekly meeting with subordinates and this continues on to the first level of supervision. Policy is further disseminated by means of the usual departmental manuals and company manuals of standard practices. Policy having to do with specific projects and affecting more than one department is published in a Manufacturing Programme Manual.

There is relatively little difficulty in establishing general operating policies or in altering them to suit changing conditions. In practice, however, constant vigilance is necessary to ensure that policies consistently get to the people in the undistorted form that is intended.

The check on the internal effects of policies is by a reverse flow up through the various echelons of supervision.

4. PEOPLE

I sincerely hope it has now been established, and is obvious to you, that the formulation of plans, creation of plant, generation and execution of policy, are *wholly* dependent upon People, previously named as the dominating element.

Furthermore, results will emerge as above-average in accomplishment only if high esprit de corps is present among these people.

The man who handles a riveting gun, the punch press operator, the rigger and fitter, the lathe operator—in fact, every person on the plant floor is, in a sense, a V.I.P. Likewise, the engineer, the tool designer, the planner, the buyer, the supervisor, the foreman, the assistant foreman, the superintendent, the department manager, the inspector, the typist and the clerk, are *all* highly important individuals.

These people are not machines. They possess pride and dignity—and the dignity of a man is something other men must respect.

Management's prime responsibility is that of building and maintaining a profitable enterprise for the benefit of all concerned.

In the case of aircraft production, the men in charge are concerned with producing a stated number of units to a certain schedule. If the production line is planned in the proper manner, with due consideration to all the foreseeable elements, they should be able to produce aircraft on a competitive basis.

But to implement the objective, management's chief concern must be sound human relations. With them, an aircraft factory will run smoothly and efficiently. Without them, management will find itself saddled with all the headaches of strikes, shut-downs, inferior work, discord and bad public relations and these, in turn, can often make the difference between red and black ink on the balance sheet at the end of the year.

Sound human relations encourage the desire for teamwork—teamwork between all concerned, both supervised and supervisory. To obtain it, the people involved must be dealt with as people and not as numbers or lines in statistical reports, graphs and trends. They must be guided by the best leadership obtainable and developed under the most enlightened "work climate" which fully appreciates the importance, dignity and uniqueness of the individual. Such conditions must be so evident by management's acts and expressions that no doubt can exist as to the genuine interest and sincerity of company officers.

Only under this policy will teamwork develop and flourish. The people concerned must hold the belief that they are directly and individually associated with a business desiring labour peace, satisfied employees and the release of willing effort for the welfare of all concerned, and not just because these things make for a profitable business.

Upon this premise, sound human relations are built and the long list of personnel handling techniques involving job evaluation, psychological testing, attitude surveys, merit rating, employee newspaper, medical programmes, training programmes, bulletin boards, suggestion systems, paid vacations and union contracts, become secondary and incidental.

Canadair has, for a considerable time, pursued the course of trying to attain objectives through the people by increasing their knowledge, keeping them informed, and adding to their skills.

Under this philosophy, the point of greatest return is reached when the day-to-day relationship between supervisor and supervised permits the real "two-way" process, so much discussed in relation to communications theory. Astounding results have been observed because people have come to act upon the basis of mutual understanding, respect and confidence. The effort willingly released under these conditions can amaze even the most skeptical.

In placing such heavy stress upon the necessity for a fundamental and personal approach to the subject of human relations, it is not intended to overlook or minimize the need for applying all the techniques available for attaining effective communication and satisfying the basic needs of all employees.

CONCLUSION

These then are the Prerequisites for Production: Plans, Plant, Policy and People.

Plans must cover every phase of production—they must tell who is going to do what and when and how often. Gaps in the information must be filled with the best estimates which can be made and the entire plan must be down on paper and in the hands of the people who are going to execute it.

Plant must be adapted to the task at hand and at the same time it must be prepared for the job ahead.

Policy must be clearly set forth and communicated down through the organization to all who are affected.

People must have the satisfaction of working conditions which offer recognition of the individual, opportunity for advancement, and security of employment. Only when such conditions prevail will the people feel and act as willing partners in achieving the economic welfare of the company.

With proper administration and coordination of these four elements, management is assured of economical production on schedule.

LIFT DISTRIBUTION ON WARPED SUPERSONIC WINGS

by B. Etkin*

University of Toronto

SUMMARY

In a previous paper[1] a method was developed for calculating the lift distribution on supersonic wings with subsonic leading edges and supersonic trailing edges and having arbitrary surface warping. The method is extended herein to cases where the leading edges are entirely or partly supersonic.

The process is essentially a numerical integration, in a form especially convenient for automatic computers. The procedure has been checked in a case where the solution is known, and differs from the analytical result by less than 1%.

NOTATION

A_1	area of leading edge element upstream of the leading edge
A_2	area of leading edge element downstream of the leading edge
a, b	lengths of the sides of a wing element (Figure 3)
$C_{m,n}$	a numeric matrix (Eq. 2, 5)
k	leading edge slope parameter (Eq. 3. 3)
L_S	lift on the portion S of the wing (Eq. 2. 8)
$_{m,n}$	indices identifying a wing element
M, N	maximum value of $_{m,n}$
M_o	free stream Mach number
p	perturbation pressure
r, s	oblique coordinates
U	free-stream velocity
x, y	cartesian coordinates
α	local wing angle of attack
$\alpha_{l.e.}$	local wing angle of attack at the leading edge
ϕ	perturbation velocity potential
ρ_o	free stream density
σ	(Eq. 2.4)

1. INTRODUCTION

In Reference (1) linearized supersonic wing theory was applied to the calculation of lift distributions on wings with subsonic leading edges and supersonic trailing edges, and which have an arbitrary distribution of angle of attack. The numerical integration method developed is intended for application to cases where analytical integration is impracticable.

In this paper the method is extended to cases where the leading edges are wholly or partly supersonic. The basic idea of the numerical integration is the same as in Reference (1). The present case is dealt with by the artifice of adding to the wing an upstream extension which has zero angle of attack and sonic leading edges.

The method was checked by applying it to a flat delta wing with leading edge sweepback of 30°, at $M_o = 2$. The numerical integration gave results for the perturbation potential within 1% of the exact linearized solution.

2. THE EQUATIONS OF THE PROBLEM

From Reference (1), Eq. (3. 1) we have that the perturbation potential at a point Q on the upper surface of a wing with subsonic leading edges is

$$\phi_Q = \int_{R_1} d\phi_1 + \int_{R_2} d\phi_2 + \int_{R_3} d\phi_3 + \ldots \quad (2.1)$$

The regions $R_1 \ldots R_3$ are identified in Figure 1. When the wing has straight sonic leading and side edges, only the region R_1 remains, and it coincides exactly with that portion of the wing which lies in the Mach fore-

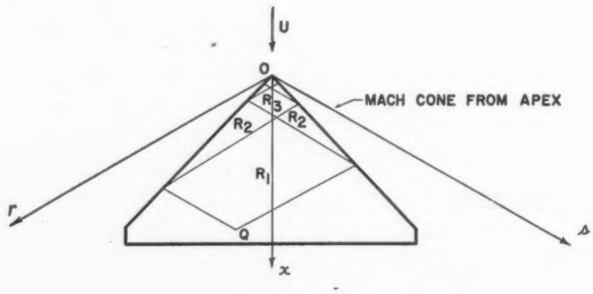

Figure 1.

Wing with subsonic leading edges.

*Associate Professor of Aeronautical Engineering.

cone from Q. This is illustrated in Figure 2. In this case Eq. (2. 1) becomes

$$\phi_Q = \frac{U}{M_o \pi} \int_{R_1} \frac{\alpha\,(r, s)\, dr\, ds}{\sqrt{(r_Q - r)\,(s_Q - s)}} \qquad (2.2)$$

The numerical integration formula derived from Eq. (2. 2) is Eq. (5. 1) of Reference (1). With a slight change in notation, it may be written

$$\phi_Q = \frac{4U}{M_o \pi} \sqrt{a\ b} \cdot \sigma \qquad (2.3)$$

where

$$\sigma = \sum_{m=1}^{M} \sum_{n=1}^{N} C_{m,n}\ \alpha_{m,n} \qquad (2.4)$$

and

$$C_{m,n} = \left(\sqrt{m} - \sqrt{(m-1)}\right)\left(\sqrt{n} - \sqrt{(n-1)}\right) \qquad (2.5)$$

The quantity $C_{m,n}$ is a numeric matrix, which needs to be calculated only once. This matrix is given in Table 1 for values of m and n from 1 to 10. The meanings of a, b and $\alpha_{m,n}$ are illustrated in Figure 3. In deriving Eq. (2. 3) it is important to note that α is assumed to be approximately constant in each element and equal to $\alpha_{m,n}$.

The primary reason for the simplicity of the integration formula obtained when the leading edges are sonic, is that the region of integration, R_1 of Figure 2, has all four edges parallel to the Mach lines. When we deal with supersonic leading edges, the shape of the region of integration loses this symmetry. This is illustrated for two typical points Q_1 and Q_2 in Figure 4. However, the shape of the region of integration can be made the same

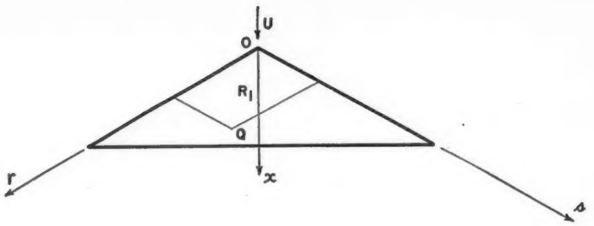

Figure 2.
Wing with sonic leading edges.

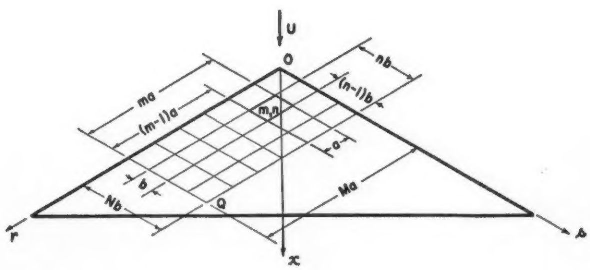

Figure 3.
Subdivision of the region of integration. $\alpha_{m,n}$ = average value of α in the element $(_{m,n})$.

TABLE I.

Numeric Matrix $C_{m,n}$

$$C_{m,n} = \left(\sqrt{m} - \sqrt{m-1}\right)\left(\sqrt{n} - \sqrt{n-1}\right)$$

n \ m	1	2	3	4	5	6	7	8	9	10
1	1	.4142	.3179	.2679	.2361	.2134	.1963	.1826	.1716	.1623
2	.4142	.1716	.1317	.1110	.0978	.0883	.0813	.0756	.0711	.0672
3	.3179	.1317	.1010	.0852	.0751	.0678	.0624	.0580	.0546	.0516
4	.2679	.1110	.0852	.0718	.0633	.0572	.0526	.0489	.0460	.0435
5	.2361	.0978	.0751	.0633	.0557	.0504	.0463	.0431	.0405	.0383
6	.2134	.0883	.0678	.0572	.0504	.0455	.0419	.0390	.0366	.0346
7	.1962	.0183	.0624	.0526	.0463	.0419	.0385	.0358	.0337	.0319
8	.1826	.0756	.0580	.0489	.0431	.0390	.0358	.0333	.0313	.0296
9	.1716	.0711	.0546	.0460	.0405	.0366	.0337	.0313	.0294	.0278
10	.1623	.0672	.0516	.0435	.0383	.0346	.0319	.0296	.0278	.0263

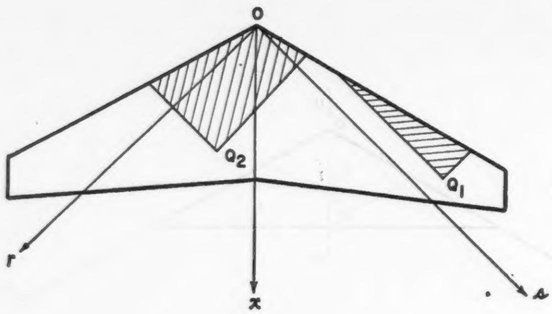

Figure 4.

Integration regions for supersonic leading edges.

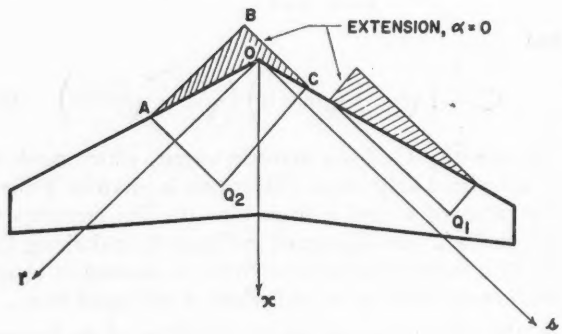

Figure 5.

Extensions with sonic leading edges and zero α.

as that for sonic leading edges by the artifice of adding an upstream extension to the wing which has sonic leading edges and zero angle of attack. This extension has no influence on the flow over the wing, since it is placed in a region of zero upwash. This is illustrated in Figure 5 for the same case as shown in Figure 4. The computation procedure for each of these points is now the same as though they were part of a wing with sonic leading edges. For example, the region of integration for point Q_2 of Figure 5 is $ABCQ_2$. These integration regions are subdivided into MN elements, as shown in Figure 3, and Eqs. (2. 3) to (2. 5) applied to compute the perturbation potential.

The elemental areas of this subdivision are of three kinds:

(1) Those which lie entirely on the wing. For these the value of $\alpha_{m,n}$ to be used is the average over the element, or for practical purposes, the value at the centre.

(2) Those which lie entirely off the wing, in the zero α extension. For those, $\alpha_{m,n} = O$.

(3) Those which are cut by the leading edge. For these elements it is assumed that a suitable average value of $\alpha_{m,n}$ is obtained by taking the simple area average over the element. This is illustrated in Figure 6. Visual estimation of the ratio $A_2/(A_1 + A_2)$ appears to give satisfactory accuracy.

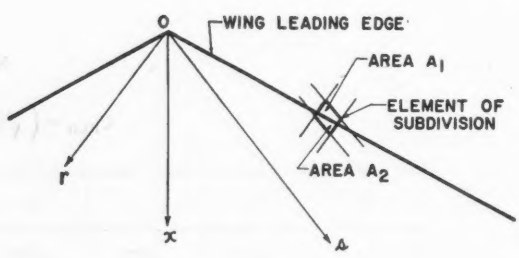

Figure 6.

Estimation of $\alpha_{m,n}$ at leading edge elements

$$\alpha_{m,n} = \alpha_{l.e.} \frac{A_2}{A_1 + A_2}$$

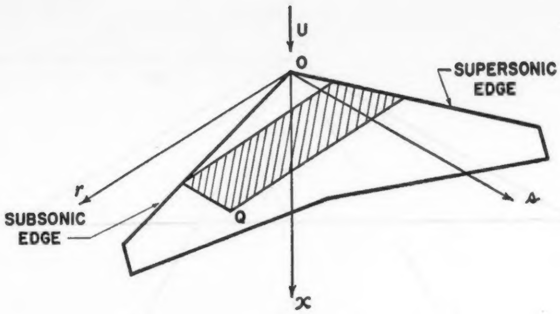

Figure 7.

Integration region for mixed leading edges.

Mixed Leading Edges

When the forward running Mach lines from the point Q intercept one supersonic and one subsonic edge, Evvard[2] has shown that the appropriate region of integration for Eq. (2. 2) is that shown hatched in Figure 7. Such regions may be altered to have the desired parallelogram shape by adding an upstream extension to the supersonic edge just as in the case of leading edges which are entirely supersonic. This alteration is illustrated in Figure 8.

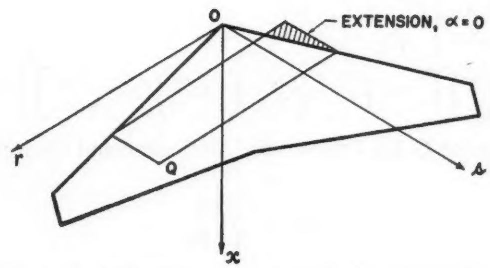

Figure 8.

Zero α extension for mixed leading edges.

Lift Distribution

The local pressure difference across the wing, or the local lift per unit area, may be obtained from the perturbation potential by the well known formula[1]

$$\frac{\Delta p}{\frac{1}{2}\rho_0 U^2} = \frac{4}{U}\phi_x \qquad (2.6)$$

or

$$\Delta p = 2\rho_0 U \phi_x \qquad (2.7)$$

If the actual lift distribution is required, ϕ_x may be determined by a numerical differentiation of ϕ in the x direction. However, it is frequently the case that what is required is not $\triangle$ p, but the load on certain finite portions of the wing, e.g. area S in Figure 9. The leading and trailing edges of the area are denoted x_l (y) and x_t (y). This load is given by

$$L_S = \int_{y_1}^{y_2}\int_{x_l(y)}^{x_t(y)} \Delta p \, dx \, dy$$

$$= 2\rho_0 U \int_{y_1}^{y_2} dy \int_{x_l}^{x_t} \phi_x \, dx \qquad (2.8)$$

$$= 2\rho_0 U \int_{y_1}^{y_2} \Delta\phi(y) \, dy$$

where $\triangle\phi(y) = \phi_t(y) - \phi_l(y)$ is the difference in the perturbation potential between the leading and trailing edges of S at a fixed spanwise station y.

The load L_s is thus given rather simply by a numerical integration in the spanwise direction of the potential difference $\triangle\phi$.

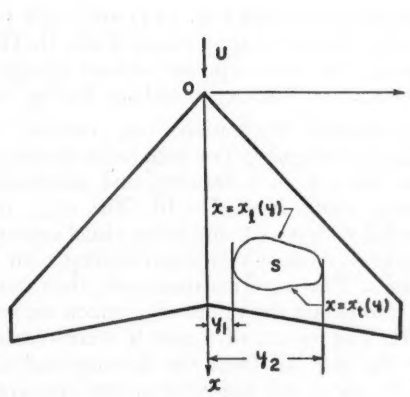

Figure 9.

Integration of the load on a finite portion of the wing.

3. NUMERICAL EXAMPLE

The only part of the method which requires verification by a numerical example is the treatment of the leading edge elements. All the other features have been tested in Reference (1). To this end the wing chosen for computation is a flat delta wing with leading edge sweepback of 30° in a stream of $M_o = 2$. This is a case of conical flow, for which the exact linear solution is readily computed by integration of Eq. (2.2) in oblique coordinates. In this integration $\alpha(r, s) = \alpha$, a constant, and R_1 is the portion of the wing in the Mach fore-cone from Q, as shown in Figure 4.

The integration has been carried out, with the following results:

when Q is within the Mach cone from the apex

$$\phi_Q = \frac{U\alpha s_Q}{M_0\pi}\left\{\frac{\pi(1+k)}{\sqrt{k}}\left(1+\frac{r_Q}{s_Q}\right) - \frac{2}{\sqrt{k}}\left[\left(\frac{r_Q}{s_Q}+k\right)\tan^{-1}\sqrt{\frac{r_Q}{k s_Q}}+\left(1+k\frac{r_Q}{s_Q}\right)\tan^{-1}\sqrt{\frac{s_Q}{k r_Q}}\right]\right\} \quad (3.1)$$

and when Q lies between the Mach cone and the leading edge

$$\phi_Q = \frac{U\alpha s_Q}{\sqrt{2}\,M_0} \quad (3.2)$$

For the example chosen, the numerical data are as follows (see Figure 10):

$$\Lambda = 30^\circ$$
$$\mu = \sin^{-1}\frac{1}{M} = 30^\circ \quad (3.3)$$
$$k = \frac{1-\tan\Lambda\tan\mu}{1+\tan\Lambda\tan\mu} = \frac{1}{2}$$

For convenience the quantity computed was $\frac{M_0\pi}{U\alpha s_Q}\phi_Q$.

The results obtained from Eqs. (3.1) and (3.2) for four values of the ration r_Q/s_Q are given in Table II. The solution for point No. 4 also applies without change in the region between the Mach cone and the leading edge.

The numerical integration was carried out as described in the foregoing. For each point the integration region was laid out on a drawing, and subdivided into 100 elements, using $N = M = 10$. The $\alpha_{m,n}$ matrices were recorded with $\alpha = 1$, and using visual estimation of the area ratio $A_2/(A_1 + A_2)$ when dealing with leading edge elements. The $\alpha_{m,n}$ matrices were then multiplied by the $C_{m,n}$ to obtain the values of σ, which are recorded in Table II. The values of a and b were obtained by measuring Ma and Nb from the drawing and dividing by M and N, and s_Q was measured on the drawing. Then from Eq. (2.3) the test quantity is given by

$$\frac{\phi_Q M_0\pi}{U\alpha s_Q} = \frac{4}{s_Q}\sqrt{a\,b}\cdot\sigma$$

These values are also shown in Table II, and can be seen to check the exact solution within 1%.

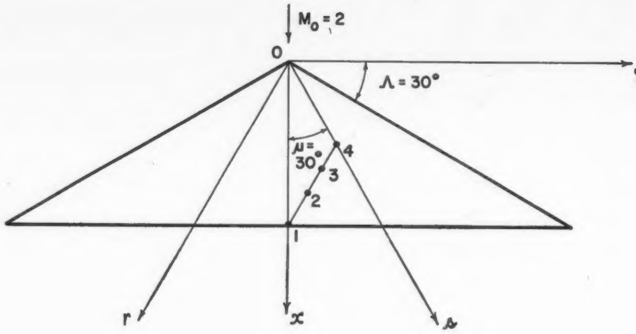

Figure 10.

Example computed.

TABLE II.

Comparison of Analytical (exact) and Numerical Results

Point No.	r_Q/s_Q	σ	$\frac{\phi_Q M_0\pi}{U\alpha s_Q}$ From Eqn. (3.1) (analytical)	From Eqn. (2.3) (numerical)
1	1.0	8.659	5.21	5.20
2	0.6	8.668	4.17	4.15
3	0.3	8.505	3.27	3.26
4	0	7.787	2.22	2.20

4. CONCLUSION

The method of Reference (1) for calculating lift distributions on supersonic wings with arbitrary surface warping has been extended to cases where the leading edges are wholly or partly supersonic. The method has been tested by a numerical example, which shows that it gives results differing from the exact linear theory by an amount less than the error in the linear theory itself.

REFERENCES

(1) Etkin, B., and Woodward, F. A.—"*Lift Distribution on Supersonic Wings with Subsonic Leading Edges and Arbitrary Angle of Attack Distribution*", PROCEEDINGS, SECOND CANADIAN SYMPOSIUM ON AERODYNAMICS, 1954, INSTITUTE OF AEROPHYSICS, UNIVERSITY OF TORONTO.

(2) Evvard, J. C.—"*Use of Source Distributions for Evaluating Theoretical Aerodynamics of Thin Finite Wings at Supersonic Speeds*", NACA REPORT No. 951. 1950.

C.A.I. LOG

SECRETARY'S LETTER

THE CANADIAN AERONAUTICAL JOURNAL

WELL, here is the Journal which we have talked so much about. We have had every form of advice; we have been told that we cannot fail to make a success of it and we have been told that we are very foolish to attempt anything so ambitious. The Publications Committee has been going to bed muttering wise saws about never knowing what you can do till you try, and not trying to run before you can walk; after several sleepless nights it decided to recommend to the Council that we should have a crack at it. That the Committee reached this decision is largely due to the encouragement it received from Dr. Garnet Page of *Chemistry in Canada*, the journal of the Chemical Institute of Canada, and if the CANADIAN AERONAUTICAL JOURNAL proves to be a success —as I am sure it will—we must remember this further debt which the C.A.I. owes to a sister Institute.

It will be noted that the Log lives on in the "news" section of the Journal. The emphasis, however, has shifted. The primary function of the Institute and its Journal is to disseminate technical information; the news, the Log of the C.A.I., is secondary and assumes a secondary position in the general arrangement.

A good deal of thought has been given to the matter of advertising. Some of our members feel that advertising has no place in a technical publication of this sort, but the Publications Committee and the Council have taken the view that, provided the advertising is not allowed to interrupt the reading matter, it does not detract from the Journal and that the income which it provides is important in helping to produce a publication which will be a credit to the Institute and to Canadian aviation. Personally I believe that advertising does something more; it renders a service in acquainting our members with the various products available to their daily work; it reflects current practice and introduces among the gentle shades of theory the bright colours of practical engineering; it is an essential part of a Journal which is a living community of learning, domestic gossip and everyday shopping.

C.A.A.R.C.

On the 26th February the President and the Ottawa members of the Council and Advisory Committee gave a small party to the visiting Co-ordinators of the Commonwealth Advisory Aeronautical Research Council and to the Director of the N.A.E. and those of his staff who were concerned with the visit. The visitors were Mr. C. H. E. Warren, Dr. R. C. Pankhurst, and Mr. D. G. A. Rendel from the United Kingdom, Mr. D. G. Hurley, Mr. F. G. Blight, and S/L J. A. Rowlands from Australia, and Mr. W. J. Rainbird from New Zealand. It was a great pleasure to meet them during their short and busy visit to Canada, and we hope that some day they will come back with more time to spare and will present a paper or two before the Institute.

VANCOUVER

The Vancouver Branch is getting into its stride. Early in March I had a very pleasant visit from Mr. Siers, the Secretary of their Interim Committee and now one of their 1955-56 Councillors, and I was able to talk over some of their problems with him. (I had previously had a 'phone conversation with their Chairman, Mr. Cameron, as he passed through Ottawa, but unfortunately we were unable to meet.)

I think that it is important to the Institute that every effort should be made to strengthen the bonds between Vancouver and the older Branches. I hope that anyone from Montreal, Ottawa or Toronto whose business carries him to Vancouver will make a point of getting in touch with some of the Executive Committee of the Vancouver Branch and will, if possible, attend one of their Branch meetings.

We must also learn to exchange speakers between the East and West. I realize that most of these transcontinental journeys are made at short notice, but if anyone has any long range plans for such a journey and if he is prepared to speak to the C.A.I. at the other end—I am addressing these remarks to both East and West—I should be glad if he would let me know so that arrangements can be made.

BRANCHES

NEW BRANCHES

With the introduction of the Journal it would be well to review the procedure for the creation of new Branches. The strength of the Institute lies in its Branches, for it is in the Branches that the routine work of the Institute is carried on; apart from the Branches the Institute has no organized being and even the Council is composed, not of members elected by the membership as a whole, but of representatives of the Branches, elected by the members of the Branches—in fact, members who are situated beyond the reach of any Branch have no representation on the Council. The development of new Branches is therefore of great importance if the C.A.I. is to serve its far-flung membership.

When it becomes apparent from the Headquarters records that interest is growing in any particular locality, one of the members there is invited to act as "Interim Secretary". If he accepts, his name and address are published in this column and his function is to provide a local contact, from whom would-be members can obtain application forms and information about the Institute. He is given a list of the members in his district so that, if he wishes, he can call upon them to form an Interim Committee to help him in promoting interest and in encouraging friends and acquaintances to apply for membership; this Interim Committee may organize a social evening where plans for the formation of a Branch can be discussed.

When at least 20 people have submitted applications, and provided that there is every promise of the group going from strength to strength, the Interim Committee may apply to the Council for formal approval of the formation of a Branch.

With the granting of this approval, the Institute gives financial assistance to the new Branch, sets up the necessary system for membership card records, supplies stationery and begins to give the normal Headquarters service. At this stage, if it has not already done so, the new Branch is required to hold elections to establish a proper Executive Committee, which will include two members to represent the Branch on the Council.

At the present time the following are the names and addresses of the Interim Secretaries at various "centres of aeronautical activity"—to quote the By-laws—and the numbers of members and applicants for membership at present in their localities:—

Winnipeg Present membership 33
Mr. R. T. Gibson
P.O. Box 82,
St. James,
Winnipeg 12, Man.

Halifax Present membership 18
Professor O. Cochkanoff
Mechanical Engineering Dept.,
Nova Scotia Technical College,
Halifax, N.S.

Edmonton Present membership 23
W/C J. G. Portlock
8621 - 104 St.,
Edmonton, Alta.

Calgary Present membership 11
Mr. W. E. Jamison
Provincial Institute of Technology and Art,
Calgary, Alta.

Winnipeg and Edmonton are doing well. Though the majority of their "members" are relatively new applicants who have not yet been admitted, experience has shown that membership increases rapidly once the "20" mark has been passed and the possibility of a Branch being formed turns into a good probability.

Calgary

We had not previously published the name of an Interim Secretary for Calgary and we are very pleased to announce that Mr. Jamison has taken on the job. At present the majority of the members in Calgary are associated with the Provincial Institute of Technology and Art, but it is to be hoped that a Branch can be built up on a broader basis. Maintenance, manufacture, operation, repair and overhaul, design, research and education, each have a contribution to offer and information to exchange, and a Branch cannot be healthy or effective in promoting the objects of the C.A.I. if it is confined to only one or two of these activities.

Winnipeg

Mr. R. T. Gibson, the Interim Secretary, tells us that he recently arranged a meeting with Mr. B. W. Torell of T.C.A., Mr. W. S. Haggett, Mr. R. H. May and Mr. W. E. Robinson of MacDonald Bros. Aircraft, to discuss plans for a Winnipeg Branch. They decided to try to promote further interest in the district and to hold an election of officers when they have twenty admitted members on their books. (The chances are that they will reach this figure by mid April.—Secretary). At that time they expect to have a good many more applications in the mill and will probably apply to the Council for formal recognition as a Branch of the C.A.I.

Mr. Gibson concludes by suggesting that, if and when a Branch is formed, someone from Ottawa, Toronto or Montreal should visit Winnipeg to welcome the new Branch into the Institute. This plea confirms the point made by the Secretary at the end of his Letter in this issue.

BRANCH NEWS

Ottawa—Reported by D. Pickering.

February Meeting

Mr. L. Haworth, Chief Designer Civil Engines, Rolls-Royce Ltd., Derby, addressed the Ottawa Branch on the 16th February; his subject was "The Dart Engine and its Development". The meeting was held in the Beaver Barracks and Dr. D. C. MacPhail introduced the speaker to the 80 members who attended.

The paper threw an interesting light on the many "bugs" which plague an engine in the process of its development and Mr. Haworth's description of the troubles associated with fatigue and fretting corrosion and of his elegant solutions to these problems was most impressive.

Mr. M. S. Kuhring thanked the speaker at the conclusion of the discussion which followed the presentation of the paper.

March Meeting

About 65 members were present in the Beaver Barracks on the 9th March to hear W/C R. M. Aldwinckle, formerly of the R.C.A.F. Climatic Detach-

ment, Edmonton and now Officer Commanding, T.S.D. at Canadair Limited, give the talk entitled "Some Effects of Low Temperature on the Operation of Aircraft"[a] which he presented to the Montreal Branch in January.

G/C J. R. Frizzle introduced the speaker. The lecture was illustrated by slides and by some very impressive specimens of engine oil, polyvinylchloride, and other synthetic materials, which the speaker produced from a box containing dry ice.

After the talk, a lively discussion ensued covering such subjects as compressor efficiency, oil dilution and specification requirements. Mr. J. L. Orr, Vice-Chairman of the Branch, thanked the speaker for his valuable summary of his experience in cold weather operations.

Toronto—Reported by N. W. Hayman.

February Meeting

The February 17th meeting of the Toronto Branch of the Institute on the subject "Engine Development" was attended by more than 200 members and guests in the Economics Building at the University of Toronto.

Due to the unavoidable absence of Mr. L. Haworth, Chief Designer Civil Engines, Rolls-Royce Ltd., the talk was given by Air Commodore E. R. Pearce, Sales Manager (Aero), Rolls-Royce of Canada Ltd., who was introduced by Mr. Harry Keast, Deputy Chief Engineer, Orenda Engines Ltd.

Air Commodore Pearce began by reviewing, with the aid of slides, the basic working principles of the turbojet, indicating the variation of performance parameters, with operating conditions. He then covered the propjet in terms of propulsive efficiency and its variation with forward speed.

The speaker continued by discussing some of the early vibration problems encountered in the development of the turbojet. He then covered in detail some extremely interesting mechanical development problems and their solutions on gears, oil pumps, bearings, blades and gas leakage, engine breathing, combustion chamber life, bolts, splines and labyrinth seals. These examples gave an excellent indication of the troubles that only really begin after an engine has made its initial successful run on the test stand.

Mr. Dennis Jackson, Operations Engineer (Dart) with Rolls-Royce Ltd., led the discussion period. Mr. Jackson very ably replied to a wide range of questions on mechanical efficiency of gears, future of the turboprop, derating, coaxial turboprops, relative efficiencies of centrifugal and axial compressors, combustion chamber life and maintenance problems.

A vote of thanks to Air Commodore Pearce and Mr. Jackson was moved by Mr. Fred Buller of DeHavilland Aircraft of Canada Ltd.

March Meeting

The March meeting of the Institute's Toronto Branch was held on Tuesday, March 15, 1955, in the McLennan Laboratory, University of Toronto. A paper entitled "T.C.A.'s Planned Viscount Operation" was presented by Mr. B. W. Torell, Supervisor of Engineering, Trans-Canada Air Lines, Winnipeg. Mr. Torell was introduced by Mr. Paul Davoud, recently appointed Manager of Military Sales, Orenda Engines Ltd.

Mr. Torell began by briefly mentioning some of the activities required to establish maintenance and overhaul facilities for new aircraft. He pointed out that maintenance and overhaul costs are approximately one third of the operational costs of a civil airliner.

The speaker continued by discussing the maintenance check system that is planned for the Viscount, and the underlying reasons for these checks. Following this the six different checks were described, including the spacing of these checks in relation to the flight hours of the aircraft.

Overhaul procedures were then discussed, beginning with the 'major-minor' type overhaul. The speaker indicated the main advantages and disadvantages of this type of overhaul procedure. The 'progressive-type' overhaul was then described and its advantages over the 'major-minor' overhaul were mentioned. Mr. Torell quoted the economies in manpower experienced by one airline in switching from 'major-minor' to 'progressive' overhauls as 6% to 14% depending upon the cycle of the overhaul.

T.C.A.'s proposed progressive overhaul procedure for the Viscount was described, under which the aircraft is divided into 33 zones and requires 9600 hours to the overhaul cycle in all zones. Mr. Torell showed that there were initial man-hour penalties in a progressive overhaul procedure, but the long-run savings and the inherent flexibility of the procedure made it more desirable. Accessory unit overhaul was described. Accessory overhauls will be carried out at 1200 hour intervals, or multiples of 1200 hours, to fit in with the zone overhauls on the aircraft. Certain accessories, such as radio receivers require 'time-controlled' overhaul while other accessories require overhaul only as their condition shows need of servicing. The speaker then described the method of introducing modifications to the aircraft during overhaul, this being done to suit manloading on the shops and timing of major checks on the aircraft.

Having completed the discussion on procedures for maintenance and overhaul, Mr. Torell moved on to the operational and maintenance aspects of the Viscount. This aircraft is not radically different from piston-propeller type aircraft, the most important difference being the turbine-propellor engine. This power-plant results in slightly different engine control procedures on starting, taxiing, take-off, climb, decent and landing. As well, from the maintenance point of view the aircraft will present no extreme problems. However, one special problem has to do with proper adjustment of the linkages controlling the fuel flow, propellor, and water-methanol. The term applied to this problem is 'inter-connection'. At present the adjustments to the linkage system may take up to twelve hours, but it is hoped that this will be reduced considerably.

All the points discussed during Mr. Torell's talk were well illusrtated with slides.

After a short break, a sound film on the Viscount was shown, followed by an open question-answer session. Mr. Torell was asked to discuss a wide variety of questions including retirement of aircraft, cold-weather operation, maintenance cycles, scheduling of unscheduled maintenance and noise level.

A vote of thanks was extended to the speaker by Mr. R. B. McIntyre of DeHavilland Aircraft of Canada Ltd.

Vancouver—Reported by R. J. McWilliams.

March Meeting

A cocktail hour at the courtesy of Bristol Aero Engines (Western) Ltd., preceded the dinner meeting held in the Stanley Park Sports Pavilion on March 17, 1955. In the teeth of opposition from lovers of the Auld Sod, 66 members and guests attended the meeting.

The meeting was opened by the Chairman, who conveyed the greetings and warmest kind wishes of Dr. J. J. Green, President of the Institute, also of Mr. Ian Hamer, Chairman of the Toronto Branch. He briefly reviewed the formation of the Vancouver Branch, speaking highly of the efforts of the Interim Committee and naming its members. He spoke warmly of the assistance and encouragement given by the Institute in Ottawa, and praised the support of the Sustaining Members.

As Past-Chairman, Mr. R. J. McWilliams responded for the Interim

[a]This paper appeared in the March issue of the C.A.I. Log.

H. D. Cameron (Chairman, Vancouver Branch) and Captain J. Laurence Pritchard.

Committee, and in a few words transferred the major credit to Mr. T. W. (Tommy) Siers through whose initial efforts the various members of the Interim Committee were brought together.

Mr. R. W. Ryan, Vice-President, Canadian Pacific Air Lines Ltd., as Vice-President Transportation, A.I.T.A., responded for the Sustaining Members. He conveyed the greetings and best wishes of A.I.T.A. in all the future efforts of the Vancouver Branch.

Mr. D. MacLaren, Executive Assistant to the President, Trans-Canada Air Lines, introduced the guest speaker, Captain J. Laurence Pritchard, Past Secretary of the Royal Aeronautical Society. Reminiscing on some of his own early experiences with the Royal Flying Corps, Mr. MacLaren made us acutely aware of the affiliations of the guest speaker with the early days of powered flight and delivered a very illuminating description of the close association of our guest with the development of aeronautics internationally.

Captain Pritchard reviewed the history of aeronautics from the days of the Montgolfier Balloon and the Lillienthal Glider, to the present days of jet propulsion. He spoke in some detail of the part played by the French and British pioneers in the years prior to the First World War, and gave his audience a fresh insight into the truly remarkable achievements of the Wright Bros., Bleriot, Roe, Handley-Page and a host of others. Considerable emphasis was placed on the catalytic function of the Royal Aeronautical Society in the early days and the work that such societies have played and must continue to play in the advancement of the profession of aeronautics. The new members of the C.A.I. in the Vancouver area were inspired by the spirit, individualism and pureness of thought of their honoured guest.

Captain Pritchard showed a film "The First 50 Years of Powered Flight" which was sponsored by, and resulted from years of research by the Council of the Royal Aeronautical Society. The film represents a remarkable achievement from the points of view of documentary fact, originality of presentation, and production technique. It deserves to be jealously guarded with other annals of the progress of the human race.

Captain Pritchard very kindly made available a copy of a notice first published in the Journal of the R.Ae.S. in 1909. The notice is a message out of the past and reminds all Canadians of their aeronautical heritage.

"CANADA

An Aeronautical Society for Canada. Through the efforts of Mr. M. B. Logan, a member of the Aeronautical Society of Great Britain, an Aeronautical Society of Çanada is in process of formation at Toronto. Encouraging communications have been received from Lord Strathcona and Earl Grey, and Dr. Graham Bell has promised his assistance. Mr. Logan is acting as Secretary pro tem. His address is 99 Gloucester Street, Toronto, Ont. We congratulate Mr. Logan on his enterprise and wish the new Society the greatest success.

R.Ae.S. Journal, October, 1909".

Wing Commander D. C. S. Macdonald, R.C.A.F. thanked the guest speaker, and expressed the inspiration experienced by all present at having heard the Aviation Story from one of its pioneers.

Vancouver personalities—(l. to r.): J. Bertalino (Councillor), E. N. Atkey (Vice-Chairman), H. D. Cameron (Chairman), R. J. McWilliams (Secretary-Treasurer), I. A. Gray and G. Ades. (Unfortunately T. W. Siers, the other Councillor, does not appear in this group).

Montreal—Reported by H. H. Whiteman.

February Meeting

The February dinner meeting of the Montreal Branch was held on February 22, 1955, at the Airlines Cafeteria of the ICAO Building, with 66 members attending the dinner and approximately 40 more arriving after the dinner to hear the guest speaker. Branch Chairman Ev Schaefer drew attention of the members to the forthcoming elections for a new Executive and outlined the proposed arrangements for submission of a proposed slate to the members by means of an appointed Nominating Committee for additional nominations, if desired, from the membership.

Air Commodore H. M. Carscallen, Air Officer Commanding Air Transport Command, introduced the guest speaker, Air Commodore C. L. Annis, Acting Air Officer Commanding Air Defence Command. The subject of Air Commodore Annis' talk was "Some Trends in Air Defence Problems" and was prefaced by a consideration of the greatly increased potential in recent years of attacking forces. Increases in range, in altitude and in airspeed have made the problems of detection and interception vastly more difficult at the same time as developments in nuclear weapons have increased the effectiveness of relatively small striking forces. The problem of defence thus becomes continental in scale, rather than requiring defence of a specific limited front, and requires peripheral detection, interception within very limited time spans and a very much higher interception rate than was achieved during World War II. This situation imposes a heavy financial load on the defending country, and is in addition, extremely demanding on its electronic capabilities.

Since, however, any potential attacker is presented with the same problems of defence against counter-attack, some measure of safety is possible with adequate defence of a reprisal force. With this achieved, the situation has become virtually one of stalemate in so far as large scale intercontinental attack is concerned, leading to a situation where any aggression may take more conventional forms than strategic air attack.

Some discussion took place after the talk on the possibility of continental attack from the sea, on the potential of dispersal as a means of defence and on the problems raised in defending from attacks by guided missiles. The speaker was thanked by Mr. W. K. Ebel.

SUSTAINING MEMBERS

NEWS

PSC Applied Research Limited announces that it is extending its facilities in the form of additional laboratory space. The increased area will provide enlarged quarters for drafting, product engineering, publications, electronic engineering, and will provide generous space for a proposed new environmental testing laboratory. The new facilities include Vibration Equipment, Altitude Chambers, Humidity Chambers, Shock Testing Equipment, a 12" x 12" Wind Tunnel, and Physical Testing Equipment for analyzing the performance of relays, motors, etc. This laboratory will be available for customer use by mid 1955.

The Company also announces the production of the Airborne Profile Recorder Mk 3, an improved version of the instrument already extensively used for topographical surveys and capable of measuring ground elevation profiles to $\pm$ 10 ft. This instrument can also be used to measure terrain clearance from 1,000 to 25,000 feet as a radar altimeter.

The PSC Height Deviation Indicator forms part of the Airborne Profile Recorder when used for ground profile surveys. This unit compensates for minor deviations of the aircraft from chosen barometric flying height so that the record obtained indicates the terrain contour along the flight line. A separate recording may be made of the flying height deviations, if required. Correlation of contour data with ground position is done with simultaneous photography.

The PSC Type T678 Stabilization System is available for suspension of antenna and positional camera to assure accurate vertical height measurement in turbulent and high level flying conditions.

Furthermore PSC Applied Research Limited has recently designed and produced the Type T234 Airborne Radiation Detector (ARD), which is a continuously-recording rate meter operating on the scintillation counter principle. It is used in airborne geophysical surveys, and measures the intensity of gamma radiation due to the proximity of radioactive deposits at or near the surface of the ground.

Gamma rays of near vertical orientation are detected by the scintillations which they create in a thallium-activated sodium iodide crystal mounted in a detector head in a manner whereby they can be "seen" over a 45° solid angle. These scintillations create individual pulses in the output of a photo-multiplier tube. After amplification and discrimination, these pulses are fed to a counting-rate meter where they are integrated to produce a reading proportional to radiation intensity. This reading is provided by a panel meter and a chart recorder. The recorder provides a means of correlating such readings with other data simultaneously recorded.

The entire installation is carried within the airframe, and derives its power from the aircraft supply except for the counter high-voltage supply. This is derived from dry batteries suitably protected from temperature variations. A special cable, containing a very low-capacitance conductor for carrying the signal pulses, is used to connect the Detector Head and the Console. This cable is supplied as part of the equipment. Each unit, except the Detector Head, is supplied complete with vibration isolation mount.

Aviquipo of Canada Ltd. announces that it has been appointed exclusive sales representative and stock distributor in Canada for the American Steel Company which supplies cotter pins AN 380, 381 etc. to the Canadian market. In future large stocks of these items will be held by Aviquipo in its Montreal and Toronto warehouses and will be immediately available to meet Canadian requirements.

In addition Aviquipo has the exclusive agency for Masters Metallic Compound, a sealant comprising 80% lead in powdered form held in solution by colloidal suspension. This sealant which is a Canadian product and which has proved most satisfactory in commercial use is now in the process of obtaining approval for military purposes.

MEMBERS

NEWS

K. P. Abichandani, M.C.A.I., formerly of the Electronics Division, Canadian Westinghouse Company, Hamilton, has accepted an appointment with Lear Incorporated, Grand Rapids, Michigan.

R. J. Conrath, M.C.A.I., of Railway & Power Engineering, has been promoted to Aviation Manager of that Company.

T. McCloghry, M.C.A.I. and **J. H. Hill, M.C.A.I.,** of Orenda Engines Limited, have been transferred from Malton to the Company's facility at Nobel, Ont.

G. R. Wooll, M.C.A.I., Managing Director of Genaire Ltd., has been appointed Managing Director of Kaman Aircraft of Canada Ltd., St. Catharines, Ont.

J. W. Ames, A.F.C.A.I., has been acknowledged by the Soaring Association of Canada as the outstanding glider pilot of 1954, in recognition of his flight from Kitchener to Mountain View, Ont., last August.

J. H. Field, Technical Member, has been posted by the Department of Transport, from their Headquarters in Ottawa, to their District Office in Toronto. Mr. Field's position is that of Airworthiness Inspector.

E. B. Schaefer, A.F.C.A.I. has received a Citation of Professional Achievement from the College of Engineering, New York University, awarded on the occasion of the Centenary of the establishment of the College. This is a signal honour conferred on very few and Mr. Schaefer is to be congratulated.

J. R. C. Douglass, A.F.C.A.I., has retired on pension from Trans-Canada Air Lines. He is believed to be the first T.C.A. employee to retire on pension; he has been with the Company since 1938.

J. G. Barker, Associate, formerly Secretary-Treasurer of Canadair Ltd., has been appointed President of Vanadium-Alloys Steel Canada Ltd.

R. Willmot, Associate, has been placed in charge of Public Relations of the Hunting Associates Ltd.

PRESENT MEMBERSHIP OF THE C.A.I.

Technical	**943**
Associates	**49**
Total	**992**

The Technical grades comprise the following

Honorary Fellows	5
Associate Fellows	158
Members	492
Technical Members	250
Technicians	17
Students	21

BRANCH MEMBERSHIP AT THE 31st MARCH, 1955

Toronto	**410**
Ottawa	**323**
Montreal	**169**
Vancouver	**60**

DO NOT FAIL TO REPORT ANY CHANGE OF ADDRESS

ADVERTISEMENTS

The CANADIAN AERONAUTICAL JOURNAL is distributed to all members of the C.A.I., to Sustaining Members and Technical Libraries, thereby reaching an important group of aeronautical engineers and technical personnel in Canadian aviation. Enquiries about advertising requirements and rates should be addressed to The Secretary.

ANNUAL GENERAL MEETING

19th and 20th MAY, 1955

ROYAL YORK HOTEL, TORONTO

May 19th	Morning	Business Meeting
	Afternoon	Education and Training
	Evening	Dinner
May 20th	Morning	Aerodynamics, Manufacturing } Concurrently
	Afternoon	Operational

The Principal Speaker at the Dinner will be

DR. T. P. WRIGHT

Vice-President, Cornell University

The McCurdy Award will be presented at the Dinner by

THE HON. J. A. D. McCURDY

A complete programme is being mailed to all members.

EXHIBITS BY SUSTAINING MEMBERS

Sustaining Members who wish to take advantage of the Annual General Meeting to arrange exhibits of their products in private rooms of the Royal York Hotel, are asked to make their own arrangements with the Hotel. A bulletin board will be provided close to the Registration Desk on which notices of such exhibits can be displayed.

HOTEL RESERVATIONS

Members attending the Annual General Meeting from out-of-town and wishing to reserve rooms at the Royal York Hotel should write direct to the Hotel and, in so doing, should mention that they will be attending the meeting. It is recommended that reservations should be made at an early date.

PRESIDENT AND COUNCIL 1955-56

The Annual General Meeting will be the last function performed under the retiring Council. The Branches will have held their elections prior to the Meeting and will have elected their representatives on the new Council; these in turn will elect the new President. The names of the President and Council for 1955-56 will be announced at the Dinner.

C.A.A.R.C. CO-ORDINATORS IN CANADA

SOME years ago a co-ordination scheme was initiated within the Commonwealth Advisory Aeronautical Research Council with the purpose of stimulating co-operation and collaboration in aeronautical research in the Commonwealth.

The member countries appointed co-ordinators in the fields of High and Low Speed Aerodynamics, Low Temperature Operation and Research, Structures, Combustion and Gas Dynamics, Gusts and Meteorology and Special Instruments. The co-ordinators in the fields of High and Low Speed Aerodynamics and Low Temperature Operation and Research from United Kingdom, Australia, New Zealand, South Africa and Canada have been meeting in Canada between February 26th and March 8th. The following participated in the discussions in Ottawa:

Low Temperature Operation and Research:

Mr. D. Fraser, Chief Co-ordinator, N.A.E., Canada.

Mr. D. G. A. Rendel, R.A.E., U.K.

S/L J. A. Rowlands, R.A.A.F., Australia.

Low Speed Aerodynamics:

Dr. R. C. Pankhurst, Chief Co-ordinator, N.P.L., U.K.

Mr. D. G. Hurley, C.S.I.R.O., Australia.

Mr. P. J. Pocock, N.A.E., Canada.

High Speed Aerodynamics:

Mr. C. H. E. Warren, Chief Co-ordinator, R.A.E., U.K.

Mr. F. G. Blight, C.S.I.R.O., Australia.

Mr. J. Lukasiewicz, N.A.E., Canada.

Mr. W. J. Rainbird, D.S.I.R., New Zealand (at present at the College of Aeronautics, Cranfield) covered both fields of aerodynamics.

Dr. A. J. Roux, C.S.I.R., represented South Africa at the Ottawa meetings of co-ordinators.

Mr. J. H. Parkin, Director, N.A.E., and member of the C.A.A.R.C. Council, attended some of the meetings.

While in Ottawa the group visited the aerodynamics laboratories and the flight research facilities of the National Aeronautical Establishment. The visit to the N.A.E. Flight Research Section at Uplands included an interesting demonstration of the helicopter icing rig, with which atmospheric icing conditions can be reproduced at full scale.

C.A.A.R.C. Co-ordinators—(l. to r.): F. H. Buller (DeHavilland), Prof. T. R. Loudon (DeHavilland), S/L J. A. Rowlands (Australia), D. G. A. Rendel (U.K.), P. J. Pocock (N.A.E.), F. G. Blight (Australia), Dr. R. C. Pankhurst (U.K.), D. G. Hurley (Australia), W. J. Rainbird (N.Z.), J. Lukasiewicz (N.A.E.), C. H. E. Warren (U.K.), D. Fraser (N.A.E.), R. E. Klein (DeHavilland).

The co-ordinators were entertained in Ottawa by the C.A.I. and by Mr. J. H. Parkin, Director of the N.A.E. and member of the C.A.A.R.C. Council. Also, an informal evening party was held at the R.C.N. Mess at which the visitors were able to meet members of the N.A.E. staff working in their fields of co-ordination.

The meetings in Ottawa were followed by a tour of Canadian aircraft industry and research organizations. The group was flown from Ottawa by an R.C.A.F. DC-3 aircraft to Toronto (see cut) and to Montreal to visit DeHavilland Aircraft of Canada Ltd., the Institute of Aerophysics (University of Toronto), Avro Aircraft Ltd., Orenda Engines Ltd., P.S.C. Applied Research Ltd., and Canadair Ltd. The visit to DeHavillands included an impressive flying demonstration, in gusty weather, of the Beaver, the Otter, the Chipmunk and the Grumman S2F-1 submarine hunter. The party was invited by DeHavillands to dinner and to the National Hockey League game and saw Maple Leafs play les Canadiens.

The tour was concluded on Monday, March 7th, with a visit to the D.R.B.'s Canadian Armament Research and Development Establishment at Valcartier near Quebec. Some time was spent discussing the ballistic range technique as developed at C.A.R.D.E. and a cruciform-winged model was fired to demonstrate the facility.

AVIATION WRITERS ASSOCIATION

Sustaining Members in particular will be interested in the Aviation Writers Association Convention to be held in Toronto from the 30th May to the 4th June. It is expected that some 200 aviation writers from the U.S.A. will attend this Convention with a view to gaining an insight into Canadian aviation and their programme will include visits to Orenda Engines Ltd., DeHavilland Aircraft of Canada Ltd., the Trade Fair and the International Air Show; they will also hold a forum on International Aviation, in recognition of the 10th anniversary of the formation of I.C.A.O. and I.A.T.A.

SUSTAINING MEMBERS

Of The

CANADIAN AERONAUTICAL INSTITUTE

1954 - 1955

Aircraft Industries of Canada Limited

Alloy Metal Sales Limited

Aviation Electric Limited

Aviquipo of Canada Limited

Avro Aircraft Limited

Babb Company (Canada) Limited

Bristol Aeroplane Company of Canada Limited

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Canadair Limited

Canadian Aviation Electronics Limited

Canadian Car & Foundry Company Limited

Canadian Flight Equipment Limited

Canadian Pacific Air Lines Limited

Canadian Pratt & Whitney Aircraft Company Limited

Canadian Steel Improvement Limited

Cannon Electric Canada Limited

Chatco Steel Products Limited

Computing Devices of Canada Limited

Decca Radar (Canada) Limited

DeHavilland Aircraft of Canada Limited

D. Napier & Son Limited

Dowty Equipment of Canada Limited

Fairey Aviation Company of Canada Limited

Field Aviation Company Limited

Fleet Manufacturing Limited

Garrett Manufacturing Corporation of Canada Limited

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